

# DISCOVERY

9 DECEMBER 1957

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# ... the unerring laws

"Chemical science during the last quarter of a century has made such extended progress that our arts and manufactures assume altogether a different aspect. Those chemical arts which formerly were rudely conducted by the system termed the 'rule of thumb' are now methodically organised and arranged in accordance with the unerring laws of chemistry... Hence, not only are more accurate and uniform results obtained, but success and economy take the place of failure and waste." (Chemical News, 1859, 1, 1).

Here, in the first number of 'Chemical News' published nearly a hundred years ago, the eventual development of scientific control of the methods and means of production is welcomed perhaps a little prematurely; but in thousands of industrial laboratories to-day 'the unerring laws of chemistry,' and B.D.H. reagents, enable the conduct of the chemical arts to be successful and economical... and as civil as you please.

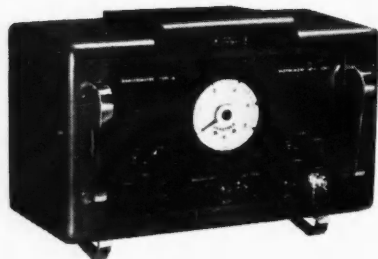


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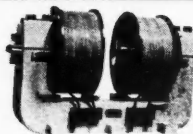
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# DISCOVERY

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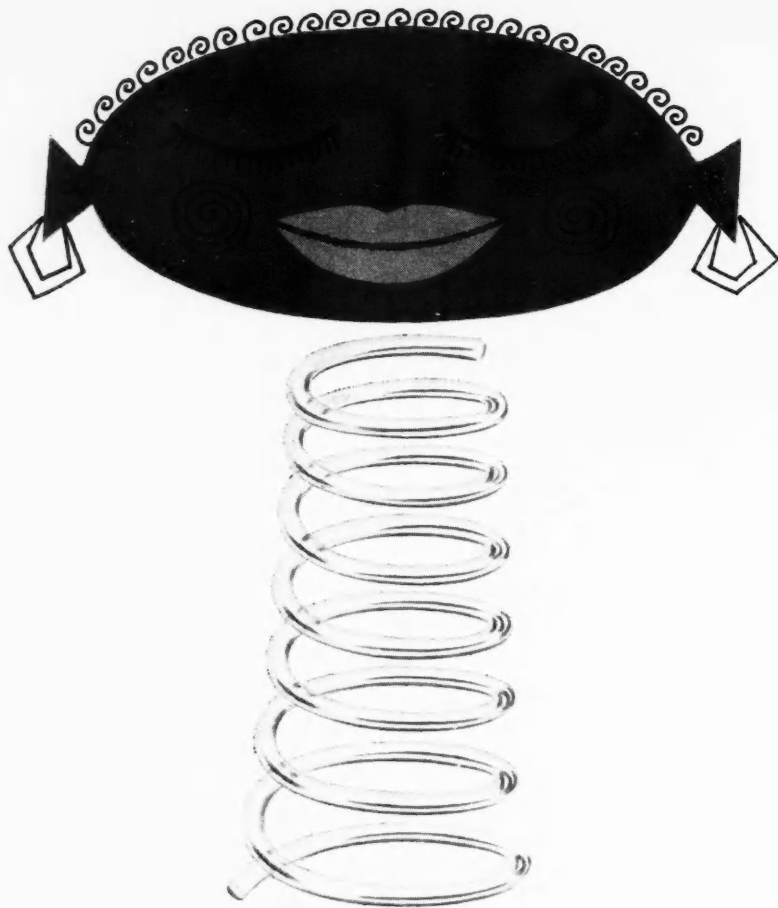
NUMBER 12

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The January issue of DISCOVERY will appear enlarged to 11" x 8½". This size will give more space for the arrangement of type and illustrations, and will allow slightly more text.

COVER PICTURE: The Lancashire coast-line, looking south towards Wales. This is one of a series of photographs taken at an altitude of 50,000 to 60,000 feet (see pp. 497-9) by Paul Cullerne, staff photographer of A. V. Roe in Manchester.



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# THE PROGRESS OF SCIENCE

## INTERNATIONALISE SPACE NOW

On Friday, October 4, 1957, the first artificial satellite was launched. Almost a month later, on November 3, the second satellite was orbiting round the Earth, containing a mammalian passenger, and by the time this issue appears it is quite possible that further satellites may have been launched. Indeed, the Age of Space Exploration has begun. The scientific and technical research that lies behind these magnificent Russian achievements has been an amazement to all, and DISCOVERY congratulates most sincerely those who were concerned in the realisation of the greatest scientific achievement of this century. These first satellites and their launching dates will be remembered in centuries to come, when present-day statesmen and scientists are but a dim memory. But now, in the next few months, is our only chance to plan the future of space exploration free from the machinations of national politics. The sky above us belongs to all men; now is the time to translate this into fact. Extraterrestrial discovery must be directed by an international body, an International Interplanetary Authority. It should here be recalled that the British Interplanetary Society was responsible in 1950 for the formation of the International Astronautical Federation. In the Constitution of this international body is a provision for "achieving space flight as a joint human enterprise", including the setting up of an International Research Institute.

There are several cogent reasons for this. Perhaps the most important is the massive expense which such research, if it is to have a chance of success, will demand. No country, not even the richest, can afford to "go this alone". Again, this research will tax all men's ingenuity to the extreme. It will need the best scientific brains in the world, whatever their native country. The know-how that the Soviet Union apparently possesses about rockets, American experience on instrumentation, and British developments in aviation medicine and space-suit design, will all be essential if man is to cross the last barrier between his planet and what lies beyond.

To get the maximum information from such a fabulously expensive experiment as projecting a satellite into an orbit it must be observed from all parts of the Earth. International collaboration for such an exercise has already been organised during the International Geophysical Year in "Operation Moonwatch". Such collaboration must continue after the IGY is finished. It is well known that if a satellite is launched tangential to the Equator, the spin of the Earth and the reduced gravitational field may be exploited, so reducing the thrust energy required. The day will come when objects launched into the sky, be they satellites or spaceships, must be able to return safely to the surface of the Earth. It will be a long time before they can be directed to a specific base; until then the whole world is their landing ground.

It is therefore essential to create, at once, an Inter-

national Interplanetary Authority. This would be responsible for all extraterrestrial activities. It would be financed by contributions from the countries of the world according to their means. That such an authority can function efficiently has been abundantly proved by the success of CERN (see DISCOVERY, 1957, November, page 460).

The Authority would immediately set up an International Interplanetary Institute charged with the duty of carrying out pure and applied research into all aspects of space exploration. It might, perhaps, be divided into eight divisions: propulsion, logistics, engineering, navigation, mathematical physics, instrumentation, astronomy, and medicine.

Probably the only major obstacle to such a plan is military security—the same security which prevented the Channel Tunnel from being built fifty years ago. At the present moment there is great secrecy about rocket development. With the United States and the Soviet Union both claiming to have produced Intercontinental Ballistic Missiles such secrecy may well be outmoded as far as the propulsion units go. Such missiles need highly complex navigational equipment to guide them to their targets, and this equipment must be safe against enemy interference. The navigational requirements for space exploration are entirely different and should not conflict with security requirements.

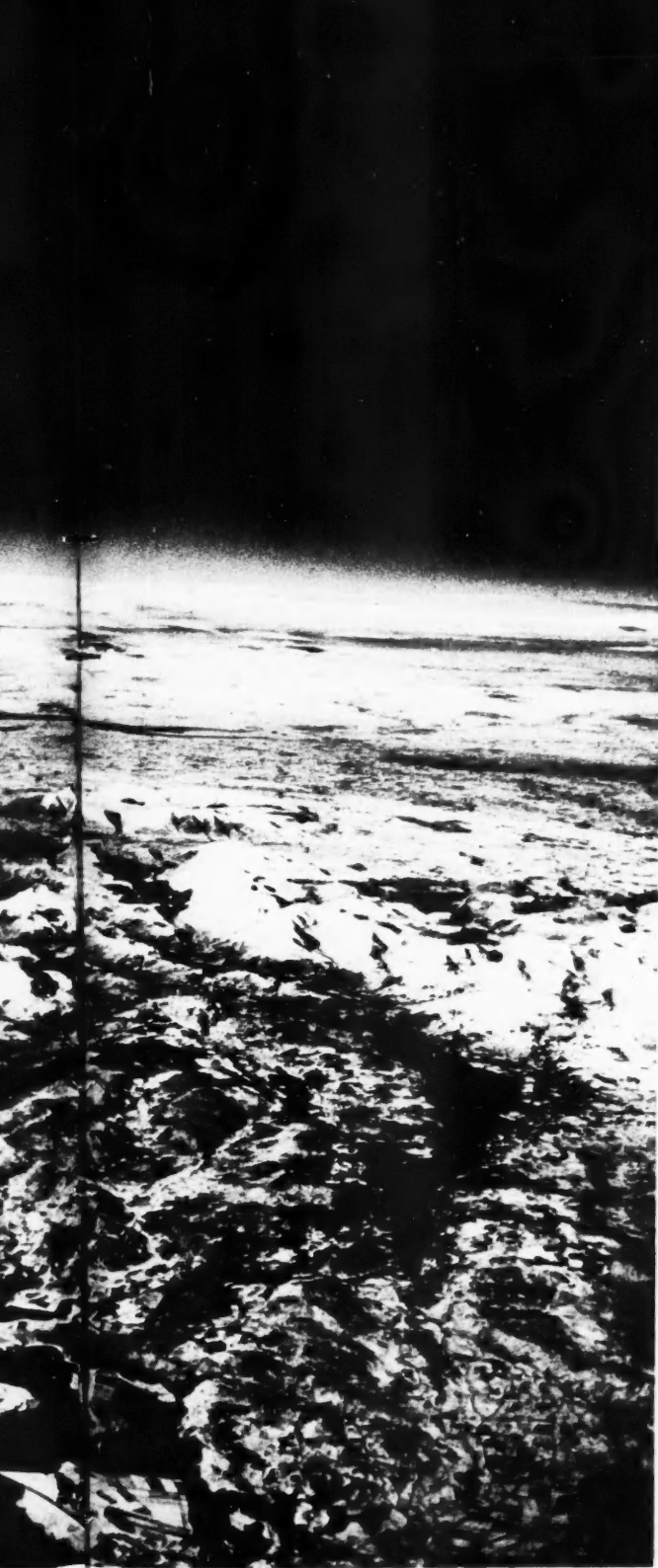
The next few months will decide whether outer space will become the arena for a battle for national prestige or whether it will become the model for future international co-operation. H.M. the Queen, when opening Parliament two days after the launching of the second artificial satellite, said, "... at this momentous time the advance of science into the unknown should be inspired by the hopes, and not retarded by the fears of mankind". Britain's scientific reputation is second to none, but as a small country, she has not even the resources to enter this race for space. However, she can play her traditional rôle of a world leader by being the first to support an International Interplanetary Authority.

## HIGH-ALTITUDE PHOTOGRAPHY

When flying in a fast aircraft at an altitude of 50,000 to 60,000 feet, the Earth looks like a vast relief map composed of papier-mâché mountains and mirror-like lakes and seas: a landscape panorama apparently devoid of human habitation, where visibility is in the range of 300 to 400 miles. Under these conditions the main problem in photographically recording such vast areas and distances is to penetrate the atmospheric haze.

Of course, moisture vapour, normally present in the air, and foreign matter such as dust, refract red light rays less than blue, and infra-red rays even less. If, therefore, we use an infra-red emulsion in conjunction with a filter transmitting only infra-red, we shall succeed in obtaining the maximum penetration through haze for our photographic record. Some precautions are



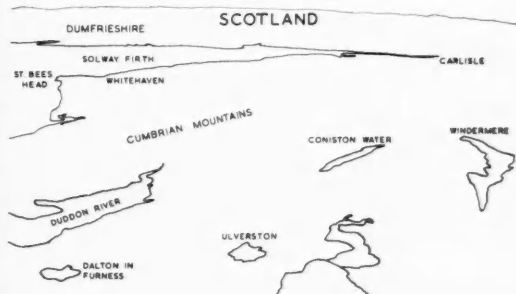


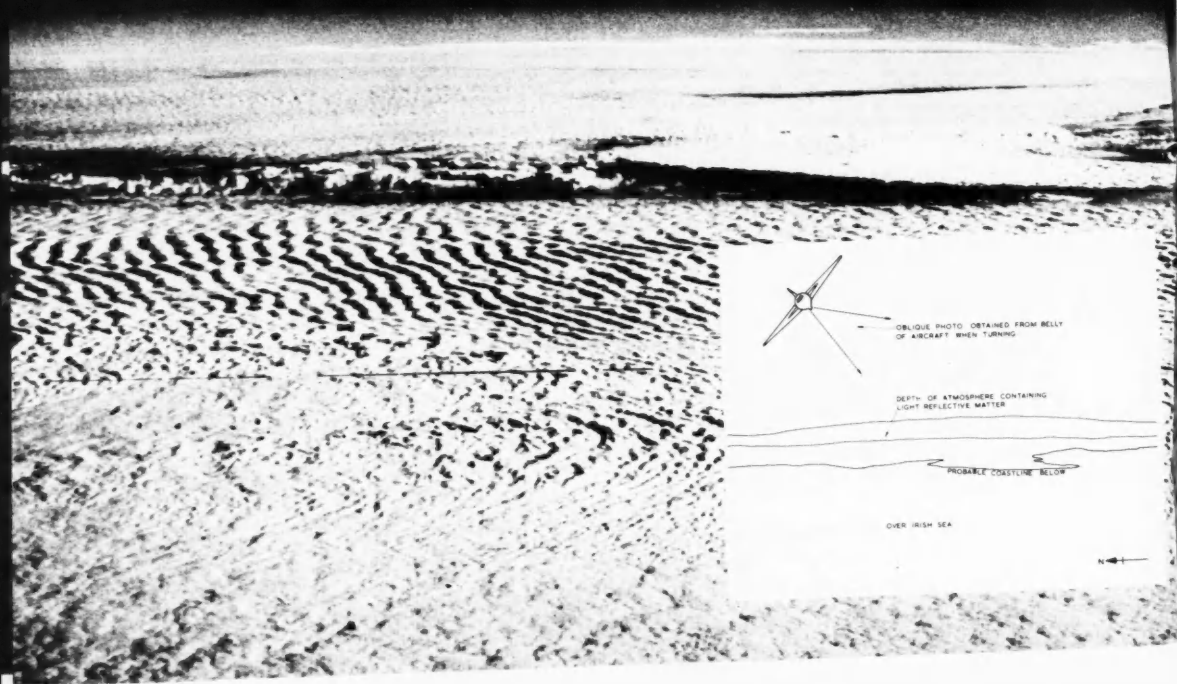
necessary when using infra-red-sensitive emulsions, as some materials used in camera construction transmit these radiations.

A camera specially designed to accept only infra-red radiations was used to record the high-altitude photographs on these pages, and, as is the case in all air-to-air photographs, great credit must be given to the pilot of the Avro Vulcan Bomber, in this case test-pilot John Baker, who was piloting the aircraft on a routine test flight from Woodford Airfield, Cheshire.

**BRITISH ISLES FROM AN  
ALTITUDE OF 50,000 FEET**  
(about 10 miles)

These superb aerial photographs, taken by Paul Cullerne of A. V. Roe of Manchester, give a vivid impression of the view that will present itself to a space traveller returning to Earth at a distance which might well in future become the territorial limits of space if the suggestions in the editorial, "Wanted a Space Law" (DISCOVERY, November, p. 452), are accepted.





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## ASTRONAUTICS IN BARCELONA

When the Seventh International Astronautical Congress was reported in DISCOVERY for November 1956, it was stated that before the opening of the next Congress an artificial satellite might already be in orbit about the Earth. The Russian Sputnik I was fired on the night of October 4-5, and the Eighth Congress was held in Barcelona from October 6-12, 1957. This can hardly have been a coincidence; such events have a habit of happening at Congress times. President Eisenhower's announcement of the existence of the Vanguard satellite programme was made while the Sixth Congress was being held in Copenhagen two years ago.

Delegates at Barcelona expected to hear another American announcement this year—one concerning the success of Project Farside, a plan to balloon-launch a large multi-stage rocket into a vertical trajectory. Four days after the end of the Congress it was learnt that unfavourable weather conditions had prevented this, though finally success was achieved on Tuesday, October 22, when the target height of 4000 miles was exceeded. This was a great step forward, and one that seems likely to yield more scientific information about the upper atmosphere than Sputnik I, if we accept the Russian statement that their satellite contains no instruments. However, the Russian achievement is obviously far more important, whether we look at it from the point of view of science, technology, military considerations, or mere propaganda.

Sputnik I has a mass nine times that of the Vanguard satellite; it is not clear what accounts for this in the present case, but evidently if the Russians have developed miniature instrumentation along the lines of that devised for Vanguard they have the capacity to carry out quite an impressive range of measurements. With a satellite mass of 184 lb., the launching vehicle must have a take-off mass of about 100 tons, placing it in the ICBM class. The mass of half a ton for the second satellite would appear to indicate that the take-off mass is even greater than this estimate.

The Russian achievement certainly overshadowed the proceedings at Barcelona. The five papers presented by their delegation were awaited eagerly and the two leading members (Prof. Sedov and Mrs Masevich, a young astrophysicist) were eagerly pursued by reporters. But they gave little information about the satellite and none at all about the launching vehicle. Only one of the five papers dealt directly with the present satellite—Mrs Masevich described the preparations for visual observation. This is by teams of students and other voluntary observers, organised in much the same way as the MOONWATCH teams in the western world. They exhibited one of the special telescopes designed for this work, and then presented it to the host society for this year's Congress, Agrupación Astronáutica Española.

The other four Russian papers were general in character and dealt with the mathematics of establishing an artificial satellite in its orbit, the determination of its lifetime, the use of satellites for investigating cosmic radiation, and the dynamics of flights to the Moon.

These papers, together with thirteen others on astronautical subjects (silicon solar batteries as power sources for satellites, rocket investigation of upper atmosphere conditions, uses of artificial satellites, and so forth) were also printed in two special supplements to the periodical *Uspekhi Fizicheskikh Nauk*, which were presented to the national societies.

Over forty papers were read at the technical sessions of the Congress, and about a quarter of these dealt with satellites of one sort or another—their use as relay stations for radio, TV, and telephony; the mathematics of their orbits and of ferry vehicles; and the recovery of manned satellites. Propulsion questions were also well to the fore, though most of the contributions in this field dealt with advanced techniques, such as nuclear propulsion and ion rockets. W. N. Neat, who is in charge of rocket propulsion at the de Havilland Engine Co., emphasised the need for developing rocket engines capable of giving thrusts variable over a considerable range. When manned vehicles are employed, the acceleration will have to be limited to a value acceptable to the crew and the apparatus carried. As missions into space become more and more ambitious, the ratio of take-off mass to final mass will be greater. With a constant-thrust engine this would mean that the acceleration would increase considerably during the period of operation of the engine. Hence some means must be provided to limit the thrust.

This could be done by having a group of small engines and switching some off as the burning time increased, but the system would be complicated, particularly since sets of engines would have to be cut out at the same time, to ensure that the line of action of the total thrust always passed through the centre of gravity of the rocket. Mr Neat thought that it would be necessary to develop engines whose thrust could be continuously varied by altering the chamber pressure, and he considered some of the implications of this on design.

There were two contributions to the technical sessions which were even more popular than the Russian papers. These were given in conjunction by Mr Otto C. Winzen of Winzen Research Inc., and Major David Simons, Chief of the Space Biology Branch of the Aero-Medical Field Laboratory, Holloman Air Force Base, New Mexico. Mr Winzen is the inventor of the Skyhook balloons which have been used so successfully for upper atmosphere research in recent years and which are manufactured from thin poly-ethylene film. Last August, Major Simons spent over a day at a height of 100,000 feet in a specially designed capsule suspended beneath such a balloon. In effect he experienced conditions approximating to those in interplanetary space; he is known to have been hit several times by heavy primary cosmic rays but so far no biological effects have been noted, though the observations are still proceeding.

P. E. Glaser of the Arthur D. Little Corporation reviewed methods of generating temperatures up to 30,000°K. These included furnaces of various types, plasma jets, and high-intensity arcs. This paper might appear at first sight to be rather outside the scope of the Congress, but it is really quite pertinent. The higher the

temperature in the combustion chamber, the greater the thrust exerted by a rocket. The work described by Mr Glaser may lead to improved methods of propulsion. It may also bring about the development of materials of construction with a better resistance to these extreme temperatures. Such materials are needed not only for the rocket engine itself but also for the external structure, where aerodynamic heating is involved. This will be of considerable importance in the case of re-entry into the atmosphere of a rocket vehicle, whether it be an ICBM, an artificial satellite, or a spaceship. The re-entry problem must be solved for manned spaceflight to become possible.

The American delegates to the Congress naturally felt the impact of the Russian satellite more keenly than anyone else, for they had been expecting Vanguard to be first. With their characteristic generosity, they were glad that mankind had succeeded in his first step towards the conquest of space, and were full of open admiration for the Russian achievement. But they were also keen to return home and shake things up so that America

would be first in making the next major step forwards—the establishment of a manned satellite. They thought that they could do this within five to eight years.

Most of the delegates from America either make the visit to the Congress as part of their official duties in the services or on their firms' expense accounts. The Russians attending were sent by the Academy of Sciences. Delegates of other countries, including Britain, have to pay for the trip out of their own pockets, except for any assistance they might receive from their national society. There were, however, two official British observers at the Congress: the Scientific Adviser to the Air Ministry (Mr S. Scott Hall) and Mr A. W. Lines of the Royal Aircraft Establishment. This is the first time that official representatives have been sent; it is heartening to note that the Air Ministry and Ministry of Supply are taking an active interest in this subject.

The new president of the International Astronautical Federation is Mr Andrew G. Haley, a noted American air lawyer. The next Congress is to be held in the Netherlands in August 1958.

The Neanderthaloid skull exposed in the laboratory in Shanidar. Notice the heavy brow ridges cleft between the eyes. (Photograph by courtesy of the Smithsonian Institution.)



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## NEW ARCHAEOLOGICAL DISCOVERIES IN IRAQ

The archaeological expedition to Shanidar Valley in the Zagros Mountains of northern Iraq resulted in several important discoveries. Of major significance were the finding of two adult human skeletons of pre-modern type in Shanidar Cave, and the discovery of an early Neolithic village site near by, containing rudimentary architectural foundations of rough field stones. The expedition occurred during the 1956-7 season and was sponsored by the Smithsonian Institution in Washington, D.C.

The discovery of the two skeletons, as well as an earlier find, that of a child's skeleton in 1953, places Shanidar Cave among the more important Early Man sites. In western Asia it is second only to the site of Mount Carmel in Palestine in Upper Pleistocene skeletal remains. Both of the adult skeletons were recovered from the top of the Mousterian layer, the bottom-most of four stratigraphical layers at Shanidar Cave. One of the skeletons was found at a depth of 14.5 feet below the surface, and the other at about 23 feet. In both, the bones were found in an unfossilised or natural state, due to the good preservative qualities of the soil. Both individuals had suffered accidental deaths from separate rockfalls. These rockfalls may have been induced by earthquakes, which occur at intervals in this mountainous section of Kurdistan Iraq. The position of the skeletons in the upper part of the Mousterian layer at Shanidar Cave, above which was found a layer containing Upper Paleolithic artefacts very similar in type to its Aurignacian counterpart in western Europe, indicates that a very late type of Neanderthal man may be involved at Shanidar. The bottom of the Upper Paleolithic layer has been dated by the carbon-14 test as about 34,000 years old.

The shallower of the two skeletons by virtue of its stratigraphical depth is estimated to be about 45,000 years old. Although the bones in this skeleton were broken and in some instances badly shattered by the rockfall, the skeleton is fairly complete. It lay in an extended position. The force of the rockfall must have been considerable, since the vault of the skull was pushed in, and the lower jaw was badly dislocated. There was a stone across the neck, practically severing the head from the body. Another stone lay across the lower legs, cutting off the feet. The chest area was crushed in. The skeleton measured about 5 feet 3 inches long, the general stature of Neanderthaloid men. The skull, although crushed by the rockfall, was well preserved. It appears to represent a "conservative" Neanderthaloid, unlike the "progressives" of Mount Carmel, which show mixed features resembling both *Homo sapiens* and Neanderthals.

The skull of Shanidar man in fact more closely resembles that of the Neanderthal man of the La Chapelle-aux-Saints (France) find, which is a classic or conservative type. There is one very apparent exception to the resemblance. The brow ridge in the Shanidar specimen instead of being carried across above the eyes in a continuous bulge, or "torus", is broken between the eyes. There is a marked lateral flare to the brow ridges.

The low sloping forehead of the typical Neanderthal as well as the characteristic low vault of the skull is here retained. The skull is long in shape relative to the width. The lower jaw, massive and robust, has a rearward-sloping chin, also characteristic of Neanderthaloids. The face was prognathous. The teeth, showing rather heavy wear, are in very good condition. Two of the front teeth, the medial incisors, are missing, evidently lost during the lifetime of the individual since there had been some replacement of bony tissue. The front upper and lower incisors show unusually heavy wear on the surface, appearing rounded across the top. There is no protrusion of the canines. Two flints were found directly associated with the skeleton.

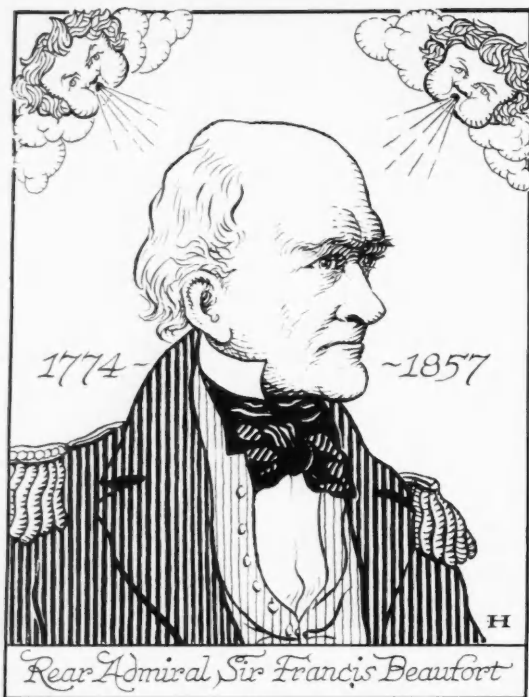
The second skeleton, not so well preserved as the first, suffered more damage by a rockfall. There is a heavy brow ridge above the eyes, and the teeth are worn quite flat. A conservative estimate for its age might be about 60,000 years.

Artefacts of chipped stone were found in the same strata as the skeletons, associated with remains of fire hearths, showing that the cave had been a habitation site. These artefacts are Mousterian in type.

The nearest locus of ancient human skeletal or paleo-anthropological finds in significant numbers is Mount Carmel where Neanderthal skeletons of both "conservative" and more humanly advanced or "progressive" types were recovered. One of the more interesting problems raised is that the Neanderthal "progressives" of Mount Carmel appear to be earlier than the Shanidar remains. It would seem that Neanderthal man of a very backward or "conservative" type languished in the mountain fastness of Kurdistan, while only 600 miles away in Palestine a type of man with some *Homo sapiens* characteristics lived and died some thousands of years before.

The skeletons, now a national treasure of Iraq, will provide another clue to the movements of the Neanderthal populations as well as to what finally became of them. Study of the one nearly complete skeleton will throw additional light on the posture of these pre-modern men who have been depicted as shuffling brutes with heavy, stooping shoulders. A recent study by Dr Muzaffer Senyürek of Ankara University of the teeth of the Shanidar child, which was discovered at a depth of 26 feet, indicates that it belongs to a new form of Mousterian or Upper Pleistocene man. Since the newly discovered adults come from higher levels in the cave, they may represent still different types of men. There is promise of additional finds, since only a portion of the cave deposits has been excavated.

The early Neolithic village site investigated by the expedition fits in the stratigraphical record of the long sequence in Shanidar Cave. The uncovered remains of the stone foundation indicate some kind of rude architecture, one of the earliest known in Mesopotamia, predating the village site of Jarmo, excavated in southern Kurdistan by the University of Chicago expeditions several years ago. It appears to equate with Karim Shahr, one of the early village sites identified in Iraq.



### FRANCIS BEAUFORT (1774-1857)

The fixing of the force and speed of the wind in meteorology was introduced by Rear-Admiral Sir Francis Beaufort, the centenary of whose death falls on December 17. Beaufort was the son of a geographer, a clergyman of County Meath, and he saw much naval action in the *Phaeton* before commanding the *Woolwich* and the *Blossom*. He suffered changes in fortune, at one time having no sea job and having to run a telegraph line from Dublin to the Galway, at another having to recuperate from severe wounds. Yet such convalescence after two occasions when he was a casualty provided an enforced leisure in which Beaufort was able to prepare his many charts of surveys in the Greek Archipelago, at Rio de la Plata, and elsewhere. For twenty-six years he served as hydrographer to the Navy, a service which brought him a K.C.B. He refused payment for his surveys and atlases since he had collected all the material while in His Majesty's service.

Although a Fellow of the Royal Society, Beaufort for some reason published his papers elsewhere than in the *Philosophical Transactions*. Thus his "Account of an Earthquake at Sea" appeared in the *Edinburgh Journal of Science* in 1826, his "Determination of the Longitude of Papeete" in the *Monthly Notices of the Royal Astronomical Society*, (1853-4), while other publications included a booklet describing the South coast of Asia Minor and his atlas drawn up for the Society for

Diffusion of Useful Knowledge. It was Beaufort who gave us the International Symbols used in describing weather, since his Notation of Weather using English letters like "b" for "blue sky, cloudless", "f" indicating fog, "o" for "overcast", and "q" for "squalls", led to symbols not dependent on a knowledge of English. But Beaufort goes down in history for his Beaufort "Numbers" quoted in everyday weather forecasts, numbers or wind scales in which his yardstick as seaman was the effect on one of his men-of-war, the *Woolwich*. Thus his "Number 6" or Force 6 meant that a ship could just carry single-reefed top-sails or top-gallants, whereas Force 12 indicated a maximum which "no canvas could withstand". Under later meteorologists, like Sir George Simpson, the original descriptions became modified to give effects noticeable on land, while Beaufort numbers (*B*) were also converted to Mean Wind Pressures ( $P=0.0105B^3$ ) and into wind speeds in m.p.h. ( $V=1.87\sqrt{B^3}$ ). Only at the end of the century were Beaufort numbers transcribed to give real velocity of winds. The Beaufort Scale thus includes the following details today:

Beaufort Number (B)	Velocity m.p.h.	Description	Examples of effects (on land)
0	Less than 1	Calm	Smoke rises vertically
1	1 to 3	Light air	Direction shown by smoke drift but not by vanes
2	4-7	Slight breeze	Leaves rustle, vanes moved
3	8-12	Gentle breeze	Leaves and twigs moved. Light flag extended
4	13-18	Moderate breeze	Raises dust and moves small branches
5	19-24	Fresh breeze	Small trees begin to sway
6	25-31	Strong breeze	Large branches moved. Telephone wires whistle
7	32-38	Beaufort's "Moderate Gale" now "High Wind"	Whole trees in motion
8	39-46	Fresh gale	Twigs broken off. Walking difficult
9	47-54	Strong gale	Slight structural damage. Chimney-pots removed
10	55-63	Strong gale or whole gale	Trees uprooted, great structural damage
11	64-75	Storm or strong gale	Widespread damage
12	More than 75	Hurricane	Countryside devastated. Winds in this class only in tropical storms, in West Indies, Far Eastern waters, and Antarctic blizzards

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# THE SPACE TRAVELLER'S YOUTH

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In recent times there has been a good deal of discussion of what people call the clock paradox of relativity. It may briefly be stated in the following form: Two people are together on the Earth; one stays on the Earth, the other embarks upon high-speed space travels, then returns to the Earth and meets the first man. Has the traveller aged just as much as the stay-at-home, or has he aged by a different amount? The problem is essentially one of the comparison of different motions, and the part of physics that is principally concerned with this kind of question is the theory of relativity. This celebrated theory falls into two quite distinct parts, the special theory and the general theory. Brief reference will be made to the character of each part, and the extent to which we have to make use of it.

## COMMON SENSE IN PHYSICS

The result (which is that the space traveller has aged less than the stay-at-home) is sometimes called unacceptable, and this requires a little discussion. The result of a theory, when applied to a particular problem, may be logically absurd and may contain internal contradictions. This would indicate that the theory has been applied to the sort of problem to which it should not and cannot be applied. In fact, no such trouble arises here, but many people dislike and disbelieve the result the theory produces because, as they say, it contradicts common sense. This is an argument so frequently brought against the theory of relativity that it deserves a little investigation.

What is common sense, and what is its use in physics? Common sense is simply the accumulated experience we have of dealing with objects and people we have come in contact with during our life. As these encounters are very frequent we have accumulated a large amount of such experience, and common sense is a splendid guide for experiences of this kind. One of the most important results of this experience is that over a wide range of objects mere scale does not matter; for example, a rolling pea will, but for the imperfections of its shape, move just like a rolling billiards ball. To some extent the motions of the molecules of a gas may be pictured by a dust storm, although the size of the particles is very different. Similarly, sitting in an aircraft going at three hundred miles an hour is not essentially different from sitting in a car and going at thirty miles an hour, or from being carried along in a sedan chair at three miles an hour. It is this irrelevancy of scale that has made it so useful for us to construct models to visualise phenomena of inconvenient size. Thus we use a glass bead to study the refraction phenomena occurring in minute water droplets that produce rainbows, and scale models in general are widely used in engineering.

In the 19th century it was thought that the main purpose of physics was to construct models of convenient

size and speed and duration to account for all the phenomena in the universe. In this century, we have learned better. We have learned that, while scale and speed and duration do not matter over a wide range, they are not irrelevant over extremely large ranges. Thus, while three hundred miles an hour is not very different from three miles an hour, and the same holds for three thousand or even three million miles an hour, the same is not true when we get up to five hundred million miles an hour, that is, when we get close to the velocity of light. Then speed does matter. Similarly, atomic theory has taught us that electrons and the nuclei of atoms do not behave like very small billiards balls, but behave quite differently. There is a limit to modelling. We cannot construct working models of convenient size and speed for all phenomena. If the speeds are very high or the sizes very small, then the familiar world of the objects around us is no guide. In these fields, then, common sense is no use at all; it is an intruder that merely befogs the issue and misleads us by applying analogies with experiences that are not analogous. We should, therefore, not be surprised if, when speeds well out of our daily experience occur in problems, the answer should at first sight appear odd and disagree with our intuitive ideas of what to expect.

## A LONG WAY ROUND

In the whole of physics one meets the distinction between two quite different classes of quantities. These may be called route-dependent and route-independent quantities. The distinction is familiar from ordinary life although it is not always appreciated. Suppose that two people set out to walk by different routes from one place over the hills to another place where they meet again. It is then clear that the mileages they have walked may well be different, but that the net gain in height (difference between height climbed and descended) must be the same for both—in fact it must be the difference in the heights of the starting and finishing places of their walks. This demonstrates the distinction between the two classes of quantities. The net gain in height in going from one place to another is independent of the route taken; it depends only on the heights of the starting and finishing points, being in fact their difference. The distance walked is a quantity of quite different nature; it depends on the route taken.

These two classes of quantities occur in the whole of physics. To give one or two examples: the change in potential energy on moving a mass (or charge) from one point to another in a gravitational or electrostatic field is independent of the route taken. The heat produced by friction in taking a spoon in a pot of honey from one place to another depends on the route taken and the speed with which the spoon has been taken over the route. And so it goes on. There are more highbrow

expressions for this division into classes, among them conservative forces and non-conservative forces, irrotational flow and rotational flow, potential fields and non-potential fields and so on, but the split occurs throughout the whole body of physics.

We can appreciate whether a quantity is route-dependent or route-independent only if we can vary the route or, to put it more strongly, only if we can vary the route appreciably. If two towns are connected by a narrow causeway which is the only way of getting from one to the other, then the inhabitants of these towns who never go elsewhere will have little conception of the route-dependence of mileage. The question of the space traveller's age is essentially the question of the route-dependence of the lapse of time. It is a question whether the time lapse between two occasions will be found to be the same by two people following different routes from one to the other or not. If, as it will turn out, the route-dependence is essentially a speed-dependence, then people who always move slowly will not be able to appreciate the route-dependence of time, and this in fact is the situation. Because our daily experience is with velocities small compared with the speed of light, we tend to think of time as a route-independent quantity. It is only when we consider theories (and the evidence on which they are based) concerned with high speeds that the route-dependence of time will become clear, although it can never be intuitively obvious to us, being outside the range of daily experience.

It will be instructive to consider the route-dependence of mileage in more detail. Suppose two motorists drive from one place to another. One follows the straight route, the other a curved one. The straight route will be shorter, as is obvious, but the connexion between the extra length of the curved route and the corners is not so clear. Suppose our second motorist follows a route consisting of a number of straight segments joined by short, sharp corners (Fig. 1). Of course his route will be longer than the route of the motorist driving along the straight road. His route will be longer *because* it curves, but the actual length of the curves themselves is quite negligible compared with the extra length of his drive. In other words, and this is the essential point of the problem, although the extra length is *due* to the curves it does not lie *in* the curves. One other point may be mentioned here. If one is a passenger in either of the two cars one will notice without looking outside whether the car is turning corners or not. One will notice the acceleration when turning the corner. Accordingly, if the two passengers compare experiences afterwards, then, without referring to the view, the passenger in the second car would say: "I knew my driver took a long and circuitous route, the corners were just terrible."

### RELATIVITY THEORY

One of the most fundamental and obvious concepts of physics is acceleration, that is, change of velocity. We know that we can feel perfectly happy and stand and balance in a smoothly running train just as though we were on firm ground. This state of affairs persists as long as the velocity of the train is constant in magnitude

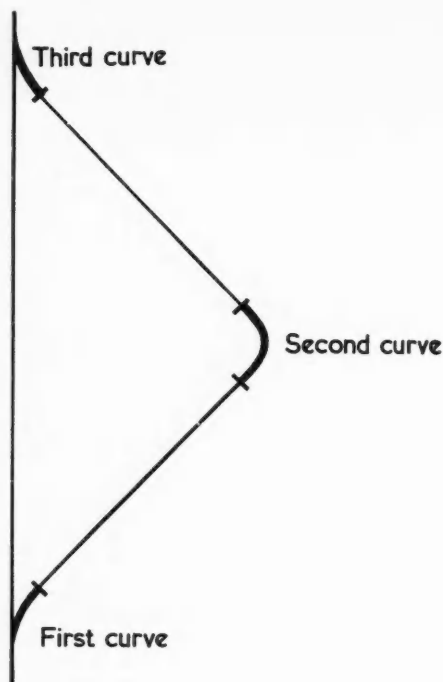


FIG. 1. Straight and circuitous travel by car.

and direction. But as soon as the train brakes sharply (or goes round a sharp bend) we have difficulty in balancing and are thrown around. Inanimate objects, like plates and glasses in the dining-car, are equally affected. As soon as there is a change of velocity—that is, an acceleration—its effects are plainly there, it can be felt. Thus there is a clear distinction between two modes of motion, accelerated and unaccelerated. Any person moving without acceleration is called an inertial observer. If an observer is inertial (unaccelerated) and a second observer is moving relative to him with uniform velocity in a constant direction, then evidently he too is unaccelerated and hence inertial. There is hence a whole family of inertial observers, moving relative to each other with uniform velocity in a constant direction, and this family is set apart from all other observers who experience accelerations and so are non-inertial. The principle of special relativity\* now states that there are no distinctions within this family of unaccelerated observers. If any one of them carries out an experiment and gets a certain result, then any other one of them could carry out the same experiment and would get the same result. A non-inertial observer might, however, fare quite

\* The fact that one speaks of the *theory* of relativity should not make the reader think that anything speculative is involved. The theory is so well confirmed by countless experiments and observations that it is one of the best established parts of physics. As there is no evidence against it at all, it would be unprofitable to doubt its predictions here.

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differently. If an inertial observer releases a particle (not acted upon by forces) initially at rest relative to him, it will stay at rest relative to him. If a non-inertial observer does the same, then, as soon as he is accelerated, he and the particle will part company.

If one inertial observer makes himself a clock, driven by a clockspring, that ticks twice a second, then any other observer copying exactly this design of clock will have a device for measuring his own time in the same way, with two ticks a second. This is not a theorem but a definition, the definition of seconds for any observer. Instead of a spring-driven clock, any other device registering time could have been used, for example the spectral line of an atom, the time a specified acid takes to eat through a specified thickness of steel, the length of a generation of rabbits on a rabbit farm, the decay of a radioactive element, the ageing of human beings, and so forth. (The problems of biological time-keeping are discussed on pp. 519-21 of this number.) Moreover, all these devices measure the *same* time when travelling with one and the same observer. If one inertial observer notes that on an average human beings travelling with him cease to grow 1000 million ticks of his spring-driven clock after they have been born, any other inertial observer would find, by virtue of the principle of relativity, that on an average human beings travelling with him would cease to grow 1000 million ticks of his spring-driven clock after they have been born.

We can now draw a diagram to represent our results (Fig. 2). Let an inertial observer, *A*, make a map of his experience by drawing time upwards, distance (in one direction only—we do not need the other dimensions of space for our discussion) horizontally. He will then represent himself by the line *AA* (being always at zero distance from himself). The marks on this line (his world line in the language of relativity) will then represent the ticks of his clock. Any other inertial observer (one moving with constant velocity relative to *A*) would then appear in *A*'s diagram in a straight line *BB* since he would cover equal distances in equal times. The steeper the line *BB*, the more slowly *B* moves relative to *A*, since the smaller the distances he covers in each period of time. Light travels very fast and so light rays are represented by rather flatter lines (drawn dashed in Fig. 2).

Another inertial observer, *C*, may be in a different position from *A*, but without relative velocity, and hence, keeping the same distance, he will be represented by a line *CC* parallel to *AA*. Suppose now that *A* sends out a flash of light each time his clock ticks (1, 2, 3 . . .) rather in the manner of a lighthouse. The flashes are received by *B* at 1', 2', 3' . . . respectively, and by *C* at 1'', 2'', 3'' . . . If *C* compares the intervals 1'', 2'', etc., with the ticks of his own clock (constructed to be identical with *A*'s clock) then it is fairly evident that these will agree, since light takes just as long to get from 1 to 1'' as from 2 to 2'', the distance *AC* being constant. On the other hand, the time taken to get from 2 to 2' will be greater than the time taken to get from 1 to 1' since the distance 2,2' exceeds the distance 1,1'. Accordingly, if *B* compares the interval 1',2' with the ticks of

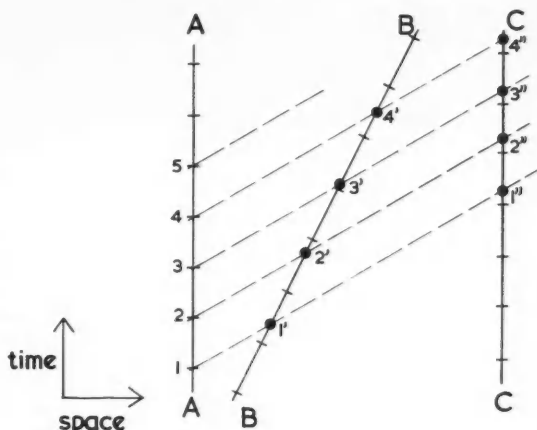


FIG. 2. Observers and light signals.

his clock (again identical with *A*'s clock), he will not get identity but will find the interval rather longer, say *k* times longer. How large *k* will be depends on his velocity of recession *v* relative to *A*, that is, it will be a function of *v*. Since *B* and *A* are identical observers\* it follows that if *B* sent out flashes of light at each tick of his (*B*'s) clock, *A* would receive them at intervals equal in length to *k* times the interval between the ticks of *A*'s clock.

Moreover, it is clear that if *B* sends out flashes at 1', 2', . . . , *C* will receive them at 1'', 2'', etc. This means that if *B* sends out flashes at intervals equal to *k* times a clock tick, they will be received by *C* at clock tick intervals, that is, the interval is now multiplied by 1/*k*. The velocity of *C* relative to *B* is evidently a velocity of approach *v*. Therefore, if a factor *k* corresponds to a velocity of recession *v*, the factor 1/*k* will correspond to the velocity of approach *v*.

The factor *k* is known from experiment as well as from theory and is greater than unity for a velocity of recession. It gives rise to the well-known Doppler shift of light which, in the case of recession, is a shift to the red, the period of the light wave being lengthened.

We are now in a position to analyse the clock paradox in the modified form due to Lord Halsbury (Fig. 3). An inertial observer *AA* is passed at *X* by an inertial observer *BB* travelling at velocity *v* relative to him and at a later instant *Z* by another inertial observer *CC* travelling relative to *A* with velocity *v* in the opposite direction to *B*. The two observers *B* and *C* pass each other at *Y*. They all carry identical clocks. At *X*, *A* and *B* both set their clocks to read zero hour. At *Y*, *C* sets his clock to read the same as *B*'s does at that instant. Does *C*'s clock show the same time at *Z* as *A*'s clock or not?

\* This is the characteristically relativistic argument. Pre-relativistically the motion of the source and the observer relative to the "ether" would have to be known. The factor *k* would depend on whether the source was moving, with the observer at rest, or the source was at rest, with the observer moving.

To analyse this, suppose that  $A$ 's clock shows  $2t_0$  at  $Z$  and that  $B$ 's clock shows  $t_1$  at  $Y$ . Since  $B$  and  $C$  are symmetrically placed observers, the interval  $YZ$  will be the same on  $C$ 's clock as  $XY$  is on  $B$ 's clock, that is, it will be  $t_1$ , so that  $C$  will read  $2t_1$  at  $Z$ . The question is then the relation between  $t_0$  and  $t_1$ .

Let  $Q$  be the mid-point between  $X$  and  $Z$  which is of course on  $A$ 's world line. Since the velocity of  $B$  relative to  $A$  is  $v$ , the distance of  $Y$  from  $A$ 's world line (that is, from  $Q$ ) in  $A$ 's reckoning is  $vt_0$ , since the period  $XQ$  is  $t_0$ . Consider now a light ray emanating from  $Y$ . It will reach  $A$  at an instant  $Y'$  such that  $QY'$  equals the distance  $QY$  divided by the velocity of light  $c$ . Hence  $QY' = vt_0/c$ . Evidently  $Y'$  is the moment at which  $A$  sees  $Y$  happening.

Let  $h$  be the interval between the successive ticks of any of the identical clocks carried by  $A$ ,  $B$ ,  $C$ . The number of ticks of  $A$ 's clock between  $X$  and  $Z$  is hence  $2t_0/h$ . The number of ticks of  $B$ 's clock between  $X$  and  $Y$  is  $t_1/h$ . If at each tick  $B$  emits a flash of light, the interval between the reception of these flashes by  $A$  will be  $kh$ . The first of these flashes will be received at  $X$ , the last at  $Y'$ . Hence in the time  $XY'$  observer  $A$  receives  $t_1/h$  flashes at intervals of  $kh$ . Accordingly

$$t_0 + v \frac{t_0}{c} = t_0 \left( 1 + \frac{v}{c} \right) = kh \times \frac{t_1}{h} = kt_1. \quad (1)$$

Now consider  $C$ . His clock will tick  $t_1/h$  times between  $Y$  and  $Z$ . If at each tick a flash is emitted, the interval between the reception of successive ticks by  $A$  will be  $h/k$ , by what has been discussed with the aid of Fig. 2. The first of these flashes will be received by  $A$  at  $Y'$ , the last at  $Z$ . Hence in the time  $XY'$  observer  $A$  receives  $t_1/h$  flashes at intervals  $h/k$ . Hence

$$t_0 - v \frac{t_0}{c} = t_0 \left( 1 - \frac{v}{c} \right) = \frac{h}{k} \times \frac{t_1}{h} = \frac{t_1}{k}. \quad (2)$$

Multiplying equations (1) and (2) we obtain

$$t_0^2 \left( 1 - \frac{v^2}{c^2} \right) = t_1^2, \quad (3)$$

whereas by dividing them we find

$$\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}} = k^2. \quad (4)$$

Formula (4) is a well-known result for the Doppler-shift, amply confirmed by experiment, whereas (3) gives the answer to our problem, namely

$$2t_1 = 2t_0 \sqrt{1 - \frac{v^2}{c^2}}. \quad (5)$$

Therefore the clock readings at  $Z$  are not identical but the reading of  $C$ 's clock is behind the reading of  $A$ 's clock. The difference in the readings,  $2t_0 - 2t_1$ , depends

very much on the velocity  $v$ . Table I gives some results for this difference if  $2t_0$  is taken to be 20 years.\*

TABLE I

$v$ (miles/second)	$v/c$	Time difference	Farthest distance attained
1000	0.0054	2 hrs 32 min	20 light days
10000	0.054	10.6 days	0.54 light yr
93000	0.50	2 yrs 8 mths	5 light yrs (a little beyond the nearest fixed star)
149000	0.80	8 yrs	8 light yrs

## ACCELERATION

In Lord Halsbury's formulation of the clock paradox three *unaccelerated* observers are used, whereas in the original formulation only two observers were used, at least one of them having to undergo accelerations. In order to consider the original problem we have hence to consider the effects of acceleration.

First, however, a common misunderstanding has to be removed. As has been said the *special* theory of relativity affirms the physical equivalence of all *inertial* observers. The *general* theory has occasionally been misunderstood to assert the equivalence of *all* observers, accelerated or not. This is, however, not so. The general theory only asserts

- the *local* equivalence of the physical effects of acceleration and gravitation;
- the need for a mathematical formulation of the laws of nature identical in *form* (though of course not in content) for inertial and accelerated observers.

As for (i), the theory immediately supplies means of distinguishing between the effects of gravitation and acceleration when *extended* regions are considered, whereas (ii) is a purely mathematical demand of no direct physical significance.

In any case, it is obvious that no theory denying the observability of acceleration could survive a car ride on a bumpy road.

Secondly, we have to consider how accelerations will show up on our space-time diagrams. Since velocity appears as slope, acceleration—that is, change of velocity—will show up as change of slope and hence as curvature. Any curved part of a world line is an accelerated one, and the sharper the bend, that is, the higher the curvature, the greater the acceleration.

Thirdly, we have to think about the effect of acceleration on clocks. As long as the motion is unaccelerated the special theory of relativity tells us quite unambiguously that it does not matter what sort of a clock is

\* Observer  $A$  should of course be unaccelerated whereas we have in mind using the Earth as  $A$ 's station. The accelerations of the Earth are small, but would affect the results given by a few seconds. The effect is important for low-speed travel (30 miles per second or so) in the solar system and, together with other effects due to gravitation, requires general relativity for its treatment.

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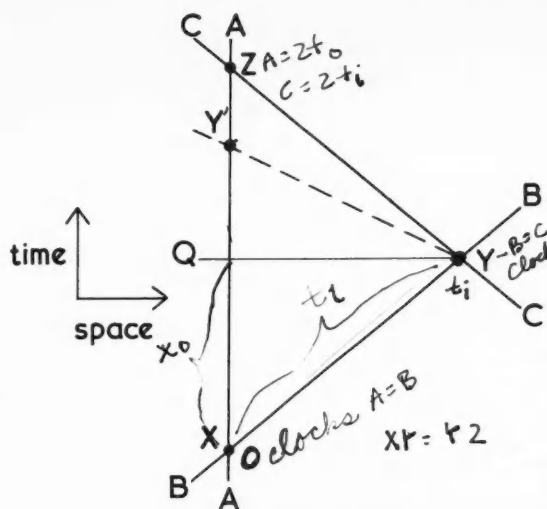


FIG. 3. The clock paradox in modified form. Does CS clock show the same time as a wrist-watch or a vibrating atom, it may be the ageing of a human being or the decay of a radioactive nucleus. Every one of these, and all other methods of measuring time, will give the same result. But if there are accelerations what can we use then? This is an important question.

We know from daily experience that different clocks react differently to accelerations. A sensitive watch dropped on a concrete floor from the height of a few inches will stop working, whereas a shock-proof watch will go on working quite happily. A human being jumping up and down for a few feet of height will go on recording time by the ageing of his body cells and by the consciousness of his brain. A human being subjected to much larger accelerations will die and will cease to measure time. A vibrating atom can indicate quite large accelerations without being affected, but it is possible to shoot it to pieces in a big atom-smashing machine, and so there are limitations to its use too. Similarly, of

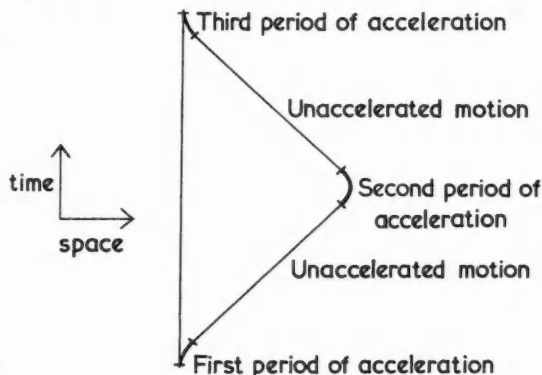


FIG. 4. Motion with short periods of high acceleration.

course, there were limitations in our earlier example to the sharpness of the corners a car could take. If they were too sharp it would overturn and that would be the end of that journey. So we must be a little careful about the use of watches and clocks in accelerated systems, but with proper limitation of their acceleration we can go on using them. We know indeed from our experience on the earth that jumping does not noticeably age us, whatever some people may say about the unhealthiness of exercise, nor does it stop our watches working or indeed falsify their readings. With a little care, therefore, this difficulty can be overcome.

Now, let us go back to the original question, and look at the space-time diagram of the earth-bound man and the space traveller (Fig. 3). The earth-bound man describes a straight path\* (neglecting the Earth's rotation, etc.). The space traveller, since he follows a different route, must follow a curved path, that is, an accelerated path. If the space traveller follows a path with short periods of high acceleration, then his path in Fig. 4 will be very close to XYZ in Fig. 3, but we must be careful about the effect of the accelerations on his clocks and on his body. If he can stand high accelerations, then his path will be so close to that in Fig. 3 that we can use the results of our work (equation (5) and Table I). The space traveller will not have aged as much as the stay-at-home. Note that although the total time during which he was accelerated was short, yet as a consequence of these accelerations his whole lapse of time is affected, just as in the case of the driver's circuitous route in our analogy before.

With these considerations the discussion of our main problem has been completed. However, in view of the accelerations required, the applicability of our results to clocks of a delicate nature like human beings is still in doubt. To take an example, if accelerations of 20g were used (an acceleration in which every object presses on its support with 20 times its normal weight) for a period of just over 10 days, a speed equal to half the velocity of light would be attained. In the example of Table I (20 years' absence of the traveller) periods of acceleration of 10 days each are so short in comparison with the length of the journey that our work there can be used, and so we find a time difference of 2 years 8 months. A radioactive material would not be affected at all by such an acceleration, and its decay would show the effect clearly. A human being, on the other hand, would die. Can we devise a mode of acceleration that will be tolerable to humans? If we want to be careful about our space traveller's health, then we must not subject him to violent accelerations. He can reach high speeds by suffering accelerations of only very moderate magnitude for a long time. Technically, it is impossible to construct such a space-ship, but here we are not concerned with engineering possibilities but with biology. We can, then, imagine a space-ship whose acceleration is always thirty-two feet per second<sup>2</sup>.† Then the space

\* Note that there is only one straight path between two events. All other paths are necessarily curved.

† For short periods when near the Earth's surface somewhat higher, but wholly tolerable, accelerations would have to be endured.

TABLE II

A	B	C	D	E
36 days	nearly 36 days	5 mins 20 secs	Pluto (38.34 AU)	0.025
3 mths	nearly 3 mths	1½ hrs	1½ light days	0.064
1 yr	nearly 1 yr	2 days 16 hrs	23 light days	0.25
4 yrs	3 yrs 6 mths	6 mths	0.85 light yrs	0.72
40 yrs	11 yrs 9 mths	28 yrs 3 mths	18 light yrs	0.995
400 yrs	20 yrs 8 mths	379 yrs 4 mths	198 light yrs	0.99995
4000 yrs	29 yrs 7 mths	3970 yrs 5 mths	1998 light yrs	0.9999995
40000 yrs	38 yrs 7 mths	39961 yrs 5 mths	19998 light yrs (nucleus of our galaxy)	0.999999995

A: Time between departure and arrival of space traveller measured by a clock on the Earth.

B: Time between departure and arrival of space traveller measured by the space traveller's clock.

C: Difference A-B.

D: Farthest distance reached.

E: Ratio of highest speed attained to the velocity of light.

The equations from which the figures are derived are:

$$\frac{fs}{c} = \log_e \left[ \frac{ft}{c} + \left( 1 + \frac{f^2 t^2}{c^2} \right)^{\frac{1}{2}} \right],$$

$$x = c \left[ \left( t^2 + \frac{c^2}{f^2} \right)^{\frac{1}{2}} - \frac{c}{f} \right],$$

$$E = t \left( t^2 + \frac{c^2}{f^2} \right)^{-\frac{1}{2}},$$

where  $f$  = acceleration,  $c$  = velocity of light,  $t = \frac{1}{4}A$ ,  $s = \frac{1}{4}B$ ,  $x = \frac{1}{2}C$ .

traveller will feel very much at home inside the spaceship because conditions there will be identical with conditions on the Earth in every way, acceleration taking the place of gravity. Proceeding in this manner for a few years and then reversing the direction of acceleration and later on reversing it again, he can go very far indeed and come back, and yet never suffer unhealthy conditions that might affect his rate of ageing (Fig. 5). It is true that he will feel a little giddy on the two occasions when the acceleration changes direction but one would not expect space travel to be the one form of travelling free of travel sickness. The theory of relativity can be used to work out the time lapse recorded by the traveller and other details of his journey, as shown in Table II.

Whatever the mode of acceleration of the space traveller, whether short and violent or long and mild, he will know that he is being accelerated by the evidence of his senses. It will, therefore, not come as a surprise to him on his return to the Earth to find out that he has aged less than the people there, just as the traveller who took the curvy road cannot have been surprised that he covered a longer mileage than the traveller who followed the straight one. Hence there is no clock "paradox", since it is not paradoxical for two persons with different experiences to find that the consequences of their experiences differ. There is simply the result that high-speed travel makes the route dependence of time reckoning evident, whereas low-speed travel does not.

#### REFERENCES

There are several discussions of the "clock paradox" in

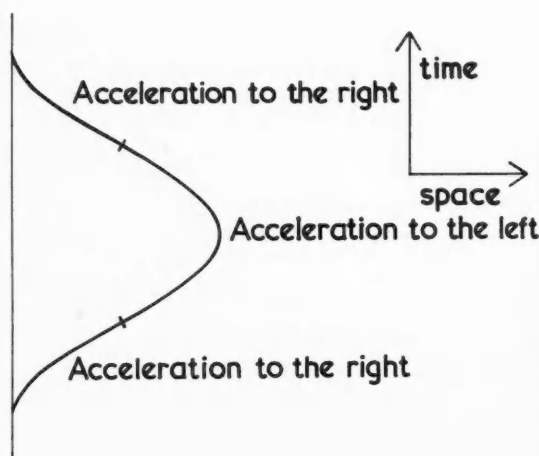


FIG. 5. Acceleration of constant magnitude with changes of direction. (A motion with constant acceleration is represented by part of a hyperbola.)

the literature, the most recent being an argument between H. Dingle and Prof. W. H. McCrea in *Nature*, vols. 177, 178, 179, in which Dingle takes an erroneous view based on the misinterpretation of general relativity referred to in this article. Lord Halsbury's formulation is given in one of Dingle's articles. Dr Crawford considers examples from physics in the same series, and acceleration is specifically considered by Sir Ronald Fisher and Prof. W. H. McCrea in *DISCOVERY*, vol. 18, p. 56 (1957).

# NEW CINE CAMERAS FOR SCIENTIFIC WORK

C. VINTEN

Managing Director, W. Vinten Ltd, North Circular Road, London

Scientists have often asked for a cine camera to be specially designed for scientific research work, but they have not always agreed on which type would be most suitable. This is because the use of cine cameras in science covers such a wide field, and because the cine camera can help in so many different ways, either to record the results of research, or as research tool itself. The three cameras described here for the first time, represent an attempt to provide cameras for scientific work which will fulfil most needs; to fulfil all is virtually impossible.

We have now developed a series of scientific cine cameras consisting of: (1) a simple recording camera, (2) a high-speed camera, and (3) a more refined camera known as the Mk II scientific camera. These three cover the general range of requirements from time-lapse recording with an intervalometer for single shots, to normal speeds of 8-16-24 f.p.s., and for a high-speed camera range from 50 to 100 f.p.s. All the cameras have 12 V. D.C. motor drive; they can therefore be driven by plugging into a car circuit, or a dry battery may be used for portable work, or a special mains rectifier unit can be supplied for laboratory use. For special purposes, such as aircraft use, a 24 V. D.C. motor can be supplied.

## SIMPLE RECORDING CAMERA

This camera has a single lens which can be easily changed to suit requirements. The camera body is provided with a tripod screw of the standard light-weight type. A sighting unit for setting up the camera can be supplied. The camera can be used with a 50-foot magazine having a daylight loading inner cassette, or with a 200-foot magazine using either 100-foot or 200-foot daylight loading spools.

## HIGH-SPEED CAMERA

This camera can be used with lenses having a range from  $\frac{1}{2}$  inch focal length to telephoto lenses. The camera has a timing device consisting of a small neon tube, which operates by an outside A.C. source, such as 110 V. A.C. mains; this will make a time mark on the edge of the film to give an accurate time scale of any high-speed phenomena. The camera also has an event marker which is a small solenoid-operated pointer; this produces a mark on the edge of the film, so that the pointer is clearly shown on each frame when an outside electrical pulse is sent through the solenoid circuit of the camera.

## Mk II SCIENTIFIC CAMERA

This type of camera is provided with a reflex shutter viewfinding system so that the scientist using it can view the picture on the ground glass while the camera is running. It is quite easy for him, therefore, to correct the focus as the subject moves away from the camera. This camera is fitted with a three-lens turret which enables changes to either short or long focus lenses, even while the camera is running. It is also fitted with a  $\frac{1}{4}$ -inch Whitworth screw in the base casting to take a light tripod.

This camera can be supplied either with a 50-foot magazine having a daylight loading steel cassette, or a 200-foot magazine using either 100-foot or 200-foot daylight loading spools. The camera can be operated for single shots by hand, or at time-lapse frequencies, by means of an intervalometer; it can also be used at cine speeds of 8-16-24 f.p.s. The camera is equipped with a governed motor to ensure constant speed.

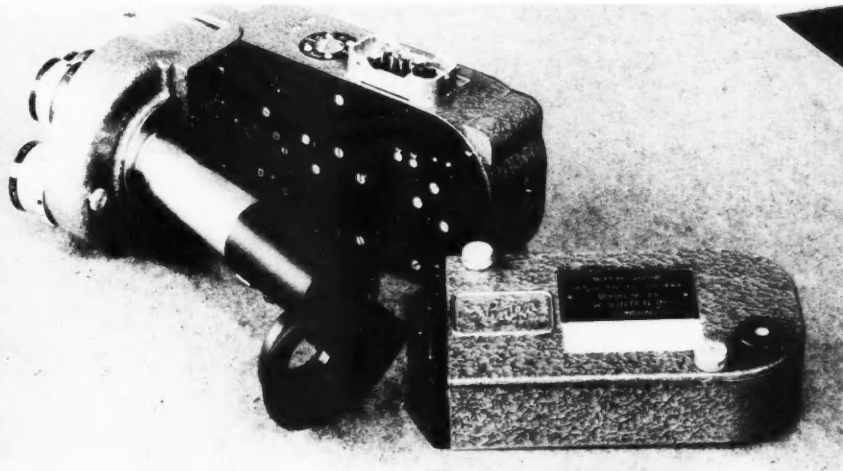


FIG. 1.  
A general view of the Mk II scientific cameras with the 50-foot magazine detached.

Every endeavour has been made to reduce camera noise to a minimum. The gear train has been designed so that a nylon gear meshes with a steel gear.

It will be noticed from the weight and dimensions given below that this camera is extremely compact, light, and handy to use. The reflex eyepiece falling naturally to the eye and the "stop"—"start" switches to the fingers of the right hand.

#### *Mk II Scientific Camera*

<b>Size:</b>	<b>Length (without lens)</b>	9.3 inch
	<b>Width</b>	5.6 inch
	<b>Height</b>	3.3 inch
<b>Weight:</b>	<b>Camera without magazine</b>	4.0 lb.
	<b>Magazine (50 feet)</b>	1.25 lb.
	<b>Cassette</b>	0.31 lb.

#### *Simple Recording Camera*

<b>Size:</b>	<b>Length (without lens)</b>	8.4 inch
	<b>Width</b>	3.3 inch
	<b>Height</b>	3.2 inch
<b>Weight:</b>	<b>Camera (without magazine)</b>	4.125 lb.
	<b>Magazine (50 feet)</b>	1.25 lb.
	<b>Cassette</b>	0.31 lb.
(All cameras use 16-mm. film.)		

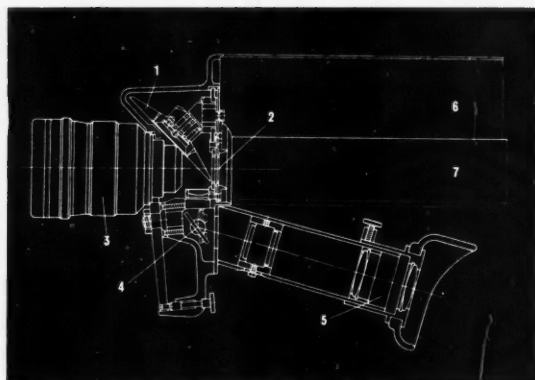


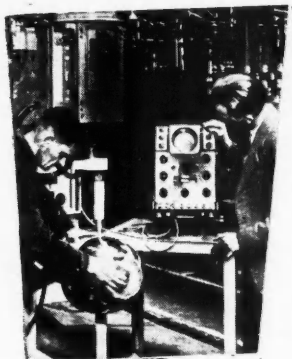
FIG. 2. A diagrammatic drawing of the Mk II scientific camera.

(1) Rotating mirror shutter. (2) Camera gate. (3) Camera lens. (4) Stationary mirror. (5) View-finder eyepiece. (6) Camera body including motor drive. (7) Magazine for film.

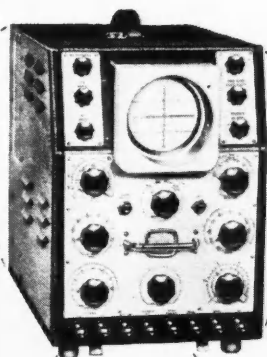
FIG. 3. Two frames taken with the high-speed camera showing the de Havilland "Firestreak" during a test flight. The originals were taken on colour film in order to measure the exhaust temperature.

(Illustration by the courtesy of de Havilland Propeller Ltd.)





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# ANIMAL LIFE IN SOILS

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It has long been realised that the soil is no mere mass of dead material in which nutrients are passed to plants by purely chemical and physical means. Rather, it is known to be a milieu of intense biological activity where the process of organic decay are intimately associated with a vast community of organisms, ranging, in the words of Fenton (1947), from bacteria to badgers.

With the exception of the microscopic Protozoa, the most abundant soil animals belong to a category which Fenton has called the mesofauna—an arbitrary middle-size group comprising forms barely visible with a hand-lens to species several centimetres in length. This group forms the main subject of the present account, and includes such animals as eelworms (Nematoda), potworms and earthworms (Oligochaeta), insects and mites, centipedes, millepedes, and other lesser-known forms such as Pauropoda and Symphyla.

## EELWORMS

The nematodes or eelworms are small unsegmented worms; and, with the exception of the transitory stages of animal parasites, soil-dwelling species are either plant parasites or free-living forms feeding on organic debris or as predators of other small organisms. In a number of plant parasites, the female completes her life-cycle by becoming a cyst packed full of eggs. Such cysts are resistant to adverse conditions and can survive for long periods in the soil in the absence of a host plant. The host range of the plant parasitic species is usually limited, and in some species the cysts are known to hatch in response to a secretion produced by the roots of the host.

The investigations of Nielson, in Denmark, indicate that most free-living eelworms are predators feeding on

bacteria and protozoa, and in the case of the larger species, on other nematodes. With the predaceous fungi, these large, free-living forms probably play an important rôle in the natural control of plant parasitic species.

## POTWORMS AND EARTHWORMS

Two families of the segmented Oligochaete worms are soil-dwelling: the potworms (Enchytraeidae), and the true earthworms (Lumbricidae). The potworms are delicate white worms which occur in soils and in organic debris not prone to rapid drying-out. They feed mainly on plant debris, though some species may eat animal remains. They do not appear to feed on living plant material, and they may, by means of a toxic secretion, be capable of destroying the larvae of nematodes that parasitise plants (Jegen, 1920, quoted by Kuhnelt, 1950).

The rôle of earthworms in soil formation is well known, and Darwin's book, "The Formation of Vegetable Mould through the Action of Worms" (1883), has become a classic of soil science. In 1777 Gilbert White, of Selbourne, observed that "Earthworms, though in appearance a small and despicable link in the chain of Nature, yet, if lost, would make a lamentable chasm." Earthworms feed mainly on decaying organic matter, and large quantities of soil particles are passed through their digestive tracts. In this way plant debris is broken down and thoroughly mixed with the mineral constituents of soil.

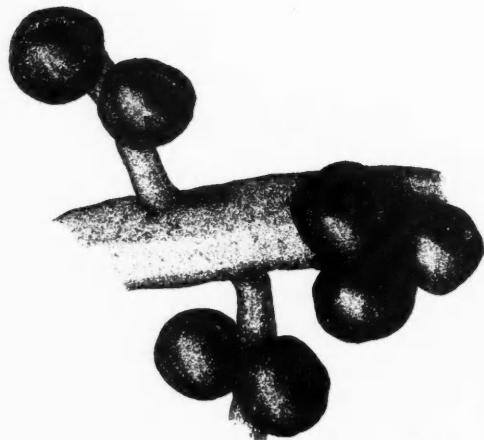
## INSECTS

While soil-dwelling insects include many familiar pests of crops, the most abundant insects in this habitat are the springtails, small, primitively wingless forms belong-

FIG. 1.  
Potato root eelworm. Mature cyst  
broken to reveal eggs and larvae.



FIG. 2.  
Potato root eelworm.  
(*Heterodera  
rostochensis*).



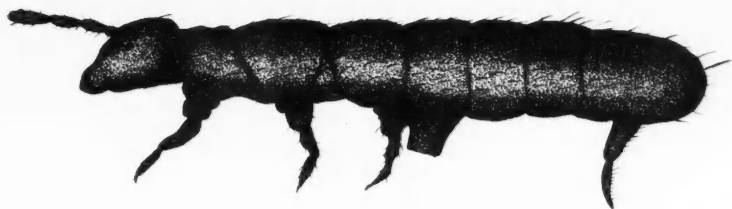


FIG. 3.  
A hemiedaphic springtail  
(*Collembola Folsomia* sp.).

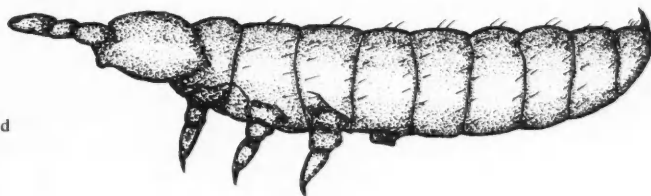


FIG. 4.  
An euedaphic springtail  
(*Tullbergia* species).  
Note the absence of springing organ, and  
relatively short antennae and legs.

ing to the order Collembola. The common name refers to a springing device found in many species on the underside of the abdomen. Another interesting characteristic of these insects is the so-called ventral tube, also located on the underside of the abdomen. In some species this tube contains protrusible vesicles which seem to be used to transfer droplets of moisture from the surface of the body to the mouth.

The numerous species living a truly subterranean life are nearly all white and blind, have short antennae, and the springing apparatus is either greatly reduced or absent. Species living on the surface herbage are pigmented, have well-developed eyes, long antennae, and a strong springing-organ. The true soil species are referred to as being euedaphic, the surface-dwelling forms being atmobiotic. Intermediate in their choice of habitat and in relation to the development of antennae and springing-organ are the hemiedaphic forms. These are mostly pigmented and inhabit the litter and the extreme surface layers of the soil.

The food of springtails is varied and most of the euedaphic and hemiedaphic species seem to feed on plant debris and fungi. There are records of their feeding on animal remains and cannibalism has been reported. Brown (1954) reports that certain species of *Onychiurus* can also feed on living plant material.\*

#### MITES

Nearly all the mites (Acarina) have eight-legged adults, and this, with other structural features, separates them from the insects. The eggs of mites hatch to produce a six-legged larva, and this in turn moults to give rise to an eight-legged nymph. Three nymphal stages (each

\* The terms which are used to describe the feeding habits of animals are as follows: forms feeding on living plants are said to be phytophagous, whilst those feeding on dead plant material are described as being saprophagous; similarly, mycetophagous animals feed on fungi; predaceous forms prey on other animals; coprophagous forms feed on animal excrement; and necrophagous species feed on the bodies of dead animals.

called an instar) may be passed through before the sexually mature adult stage is reached, although in some groups the number of nymphal instars may be reduced. The mites are a complex group taxonomically and ecologically and the soil population usually contains representatives from four major sub-groups. In the majority of soils the beetle mites or *Oribatei* are the most numerous. Many of the adult Oribatids resemble small beetles; they appear to be predominantly near-surface dwellers, although they are capable of living in the deeper soil and may undertake downward movements in response to adverse climatic conditions (Strenzke, 1952). The Oribatids have particularly lengthy life-cycles, many species taking a year or more to develop. In some mineral soils (as opposed to organic soils such as peat), the numbers of immature Oribatid mites have been found to be remarkably low in comparison with the population of the adults, and there is some evidence to suggest that many forms move out of

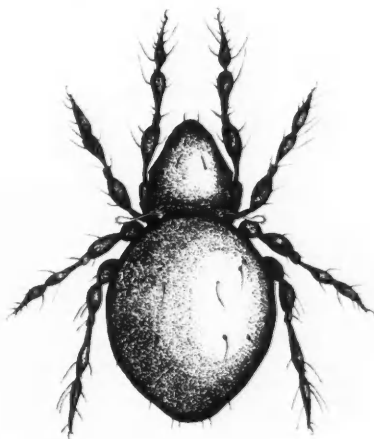


FIG. 5.  
A soil beetle  
(*Oppia* sp.).

the soil itself for reproduction. Riha (1951) found the immature stages of a number of soil-dwelling species in litter, dead wood, and in other habitats; while the nymphs of *Minunthozetes semirufus*, one of the commonest species in mineral soils, were reported by Michael (1884) to burrow in the stems of grasses. Like Collembola, the beetle mites are thought to feed mainly on plant debris and fungi, and there are reports of their feeding on lichens, mosses, and animal remains. Although not usually common in mineral soils, the curious armadillo mites (Phthiracaridae) burrow conifer-litter and other organic debris (Murphy, 1953).

Mites belonging to the group Acaridae have affinities with the *Oribatei* but lack the armour of the latter. The bulb mite (*Rhizoglyphus echinopus*) is extremely common and flourishes under conditions of high relative humidity, often seeming to live in a film of water. Recent authorities consider this species capable of feeding only on plant material previously "softened up" by bacteria. Most of the free-living Acaridae, however, prefer drier conditions and are important as pests of stored products, although there have been reports of their occurrence in collections of soil mites. Unlike the beetle mites the Acaridae have a short life-cycle and, under favourable conditions, *R. echinopus* has been observed to attain maturity in nine days. The life-cycles of many species may include an additional stage inserted between the first two nymphal instars. This is the *hypopus* and may be inert or active, according to the species. The inert phase appears to be a resistant stage. The active *hypopus* has adhesive suckers and, by attaching itself to other small animals, functions as a migratory instar assisting in the dispersal of the species.

Mites belonging to the sub-order Mesostigmata are distinguished by the presence of a respiratory opening about half-way down the body on each side. Many of the larger species of this group are active predators of small worms, springtails, and other small animals. Species belonging to the genus *Pergamasus* are common predators in British soils. The largest Mesostigmata inhabit the litter and surface soil layers but smaller forms occur in the deeper strata; these include species of the genus *Digamasellus*, which the writer has observed feeding on small springtails.

The sub-order Mesostigmata can be divided into "cohorts"; of which only two are common in soil. The first of these—the Gamasides—include most of the known predaceous forms; the Uropodina, although including some predators, are for the most part sedentary. Thus *Fuscuropoda obscura* feeds on bacterial and fungal colonies growing on decomposing vegetable material (Cummings, 1898). Mesostigmata may complete their life-cycles within three to four weeks, and some species produce migratory nymphs. In particular, nymphs of certain Gamasides are often found clinging to the bodies of other animals. These are the *nymphae coleoptrata*, so called because of their frequency on beetles. Migratory nymphs, *nymphae pedunculata*, are also found amongst the Uropodina, attachment being effected by the hardened secretion of anal glands.

The sub-order Prostigmata is a heterogenous collec-

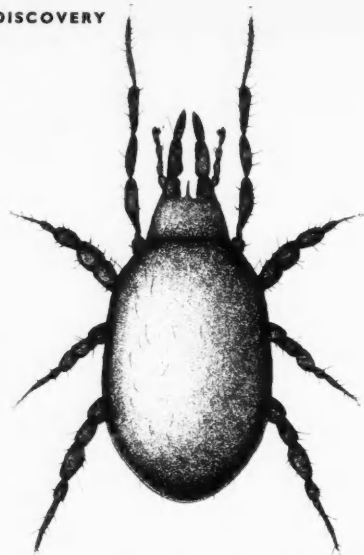


FIG. 6.  
Common  
predators  
in  
British  
soils:  
*Mesostigmata*  
*Pergamasus*  
sp.

tion of small, weakly chitinised mites with a wide range of food habits. Some of the minute tarsonemid mites feed on living plant material, an example being the bulb scale mite *Steneotarsonemus laticeps*, a well-known horticultural pest. Of the predatory forms in this sub-order, species of the genus *Cheyletus* are common in British soils.

#### MYRIAPODA

This grouping is used, for convenience, to include the millepedes, centipedes, and their allies. The millepedes and centipedes probably find their true environment in woodland soils where the millepedes play an important part in the breakdown of forest litter, the centipedes being predaceous. They sometimes occur in grassland and also in some arable soils, particularly the spotted snake millepede (*Blaniulus guttulatus*), a species capable of attacking living plants and sometimes attaining pest status. Also among the Myriapods are the Symphyla, small, centipede-like animals with well-developed antennae and never more than twelve pairs of legs. The Symphyles are predominantly saprophagous, although the glasshouse centipede (*Scutigera immaculata*) feeds also on living plants and is a pest of horticulture. Less familiar are the small Pauropoda, which are easily separated from other Myriapods by virtue of their branched antennae. They live in the surface soil, in litter and in decaying wood.

#### TARDIGRADA

The Tardigrada or bear animalcules, which constitute an isolated division of the phylum Arthropoda, may be found in the surface soil or in moss. They are thought to feed on organic debris. Tardigrades have the power of encystment and are thus able to resist highly adverse conditions. In this state they have been known to survive immersion in liquid helium at a temperature of  $-271^{\circ}\text{C}$  (Rahm, 1926).

## THE SOIL

Under microscopically present order several surface three r whilst about 1922). samples populat upper t these, 2 were m and the was 18

Recon the eno for they assessm weight c Bornebu worms i per acre worm b equivale carried t sidered t an acre stock on

The re and othe of earthy matter t large qu along the of organi Their tun influence estimated twenty to over a p depositing of organi fauna of mineral p great bio animals, (1947) al matter in ing a rôle small anim this respec soil and d "mor" soil layer abo

## THE NUMBERS AND ECOLOGY OF SOIL ANIMALS

Undoubtedly the most abundant soil animals are the microscopic Protozoa. Their numbers fluctuate enormously over short periods of time, but they are always present in at least thousands per gram of soil. Next in order of abundance are the eelworms, populations of several billions per acre having been recorded for the surface soil of pastures. Edwards (1929) found up to three million earthworms per acre in Welsh pastures, whilst in arable soil treated with dung a population of about one million per acre has been reported (Morris, 1922). Salt and his colleagues (1948), on the basis of samples taken in November 1943, estimated a total population of 1069 million Arthropoda per acre for the upper twelve inches of soil in a Cambridge pasture. Of these, 248 millions were springtails and 666 millions were mites. About 44% of the latter were beetle mites, and the population of beetles (Coleoptera) in this habitat was 18 millions per acre.

Records of this kind, while giving some indication of the enormous numbers involved, are of limited value, for they take no account of size, and a more useful assessment of the population is given by the biomass or weight of the animals in the environment. In Denmark, Bornebusch (1930) estimated that the weight of earthworms in the soil of a beech-wood was about 480 lb. per acre, whilst in other forest sites he found an earthworm biomass of about 1700 lb. per acre, and this is equivalent to the weight of livestock per acre normally carried by a first-class pasture. Wolcott (1937) considered the biomass and food consumption of insects in an acre of rough pasture to be greater than that of the stock on the same area.

The researches of Darwin (1883), Muller (1879, 1884) and others have demonstrated the important influence of earthworms in soil. By consuming decaying organic matter they accelerate further decomposition and, as large quantities of soil pass with the food material along their digestive tracts, they facilitate the admixture of organic material with the mineral particles of soil. Their tunnels and channels have an important physical influence, enhancing drainage and aeration. Darwin estimated that in some pastures earthworms brought twenty tons of soil per acre to the surface annually, and over a period of thirty years could be responsible for depositing a layer of soil seven inches deep. The mixing of organic and mineral material in soil is an important function of the larger members of the mesofauna. The fauna of soils of the "mull" type, in which humus and mineral particles are well mixed, is characterised by a great biomass due to the high population of the larger animals, especially earthworms and millepedes. Gisin (1947) also found soil particles mixed with organic matter in the digestive tracts of springtails, thus suggesting a rôle analogous to that of the earthworms, but small animals are unlikely to contribute a great deal in this respect, for they appear to use existing channels in soil and do not burrow much on their own. Hence in "mor" soils, where the humus tends to form a discrete layer above the mineral material, the population of

springtails and mites is often very high, but the larger species are poorly represented, and the biomass is low.

Saprophytic animals generally appear to play an important rôle in the early stages of organic decay by devouring plant debris, and providing in their excrement finely divided material for further decomposition by coprophagous animals, fungi, and other micro-organisms. In Holland, Van der Drift (1951) observed that, in the case of the millepede *Glomeris marginata*, there was very little difference in chemical composition between the food eaten and the excrement; consequently, as only a small amount of nutritive material was absorbed from the ingested food, large quantities of debris had to be consumed by the animals to satisfy their nutritional requirements. Many of the smaller species accelerate the breakdown in the same way. Jacot (1939) and Murphy (1953) have described the activities of the armadillo mites, *Oribatei*, family Phthiracaridae, which burrow plant residues and leave in their wake a line of frass which is subsequently washed into the soil.

Many saprophytes, however, seem loath to feed on fresh debris. Rommel (1935) noted that millepedes selected leaves previously attacked by fungi, while Van der Drift observed that although they could feed on fresh litter, his millepedes also preferred fermented material. There are grounds for suspecting that few of the higher forms of soil animals are capable of digesting on their own account the celluloses, hemicelluloses and lignins which constitute a large proportion of the plant residues. Many forms feed only on litter previously conditioned by fungi or by other micro-organisms, and there may be symbiotic relationships involving complex gut communities.

A dense population of saprophagous animals can hardly fail to influence the rate at which organic material is oxidised in soil. Bornebusch (1930) assessed the respiratory rates of a range of soil animals and showed that in the smaller species the oxygen demand per unit of body weight was much greater than in the larger forms. The food consumption of the smaller species is thus relatively greater and biomass cannot be regarded as a satisfactory measure of the activity of the animals. These respiration figures were also used to calculate the annual oxygen consumption of animal populations in various soils, and in a beech mull it was estimated that the animals alone were responsible for oxidising about 20% of the plant remains. Moreover, as their nitrogenous waste is secreted as relatively simple compounds, animal activity must accelerate the production of nitrogen in a form available to plants to a considerable degree.

Important relationships exist between the animal population and the soil fungi. Many species of the mesofauna are mycetophagous, and the predaceous fungi influence the soil nematode population. Fungal mycelia are usually scarce in soils where earthworms are abundant, although the extent to which the depression of the fungi is due to the feeding activities of the worms remains to be investigated. The requirements of earthworms include a continuous supply of calcium, and they thrive in deep soils with a more equable base status. Under these conditions fungi are scarce and bacteria

become the main agents of microbial decomposition. Earthworms are absent or rare when the pH falls below 4.5, and under these conditions (also too acidic for many bacterial groups), fungi are abundant. Hence, in soils with mor formations, fungi are the predominant micro-organisms and, developing on plant residues, their mycelia become a source of food for a legion of mites and springtails. It also appears that small saprophagous animals might encounter fungal competition (Kuhnelt, 1950) so that the balance of the community might depend on the feeding activities of mycetophagous species.

### THE INFLUENCE OF AGRICULTURE

In arable soils the mesofauna population is generally much lower than in old pasture, and this reduction appears to be related to the amount and disposition of organic material in the soil. In pastures, a surface concentration of moist organic material not only provides a source of food but also constitutes an effective buffer against changing climatic conditions. In arable soils the organic matter content is often less and the material is more evenly distributed in the profile. Consequently, in this environment the characteristic near-surface concentration of soil animals is no longer found. Applications of dung, however, result in an increase of both numbers of species and individuals, and when arable land is laid down to grass, springtails in particular are quick to recolonise, and a surface concentration of the fauna again becomes apparent. Recolonisation by beetle mites is much slower, and the population of these mites in short leys is much lower than that in old pastures. The slow recolonisation is probably due largely to the lengthy life-cycles of these mites.

In soils partially sterilised by heat or chemical treatments, resurgences of certain sections of the community have been observed. This phenomenon was first noted in bacterial populations. After the initial decimation the organisms were observed to recover quickly, and thereafter were seen to increase rapidly, attaining a population level greatly in excess of that encountered in unsterilised soil. As a result of this stimulation the amount of nitrogen available for plant growth was increased, and in this way sterilisation contributes indirectly to fertility. At Rothamsted, Baweja (1939) studied the influence of sterilisation on soil animals and observed similar resurgences in certain sections of the microarthropod population. These population changes may be due in part to the favouring of saprophagous species by the destruction of predatory forms. Even if both predator and prey are equally susceptible to the initial treatment, it has been demonstrated mathematically (Volterra, 1928) that a disruption of this sort will tend to result in an increase in the numbers of the prey and a decrease of the predatory population.

Problems of partial sterilisation have recently assumed a greater importance. Certain chlorinated hydrocarbons have been used on a wide scale for the control of eelworm pests, and although an initial destruction of nematodes is given by the treatment the residual population builds up rapidly, so that by the time the crop is harvested the nematode population frequently attains an

extremely high level. Moreover, as some of these substances are known to stimulate certain sections of the bacterial population, the increased crop-yields may be due in part to an increase of available nitrogen associated with partial sterilisation phenomena.

Investigations on the influence of the insecticides DDT and benzene hexachloride, BHC, have shown that while surface applications usually have little influence on the fauna, marked and persistent changes occur if the insecticides are incorporated with the soil by cultivation. This applies especially to the deeper-living springtails and mites; earthworms, however, are not greatly affected when these materials are used at normal rates. BHC causes drastic reductions of the deeper-living springtails and mites and these are known to persist for at least seventeen months. Resurgences of near-surface-dwelling Collembola may occur as the material is leached out of the upper strata. Laboratory tests have shown DDT to be toxic to soil mites but harmless to springtails, and in DDT-treated soils springtails have been observed to attain a high population level. This appears to be due to the reduction of predatory pressure, particularly that of the Mesostigmata. Detailed information is not yet available on the general effects of aldrin on the soil fauna, although this material is now widely used as a soil insecticide. Preliminary observations suggest that its effects are similar to those of BHC.

### CONCLUSIONS

Although much valuable research has already been carried out, our knowledge of the soil fauna is inadequate. Many animals have yet to be described and classified; and while some are well known taxonomically, their life histories, feeding habits, physiology, and ecology remain to be investigated. Only in the light of such research can the influence of these animals on soil structure and fertility be measured. The effects of chemical treatments have been shown to be profound, but an authoritative assessment of the long-term effects of such treatments on soil fertility is not yet possible. Nevertheless, it seems reasonable to suppose that the drastic reduction of saprophagous populations by persistent insecticides might constitute a danger. The increasing use of these materials in modern agriculture emphasises the need for fundamental research.

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# BIOLOGICAL TIME

C. B. GOODHART, M.A., Ph.D.

Cambridge

Prof. Bondi, in his article on "The Space Traveller's Youth", discusses the effects of acceleration on the passage of time, as measured by the ageing of hypothetical human observers, and he defines "Time" as that which is measured by the tick of a clock, or by the decay of a radioactive element, or by the length of a generation of rabbits on a rabbit farm. It is as well, however, that he sticks to rabbits, for on a frog farm he would be led badly astray; there biological events do not necessarily proceed at a regular rate with reference to physical clocks. It may be interesting to consider some of the difficulties that arise in the biological measurements of time, and to speculate upon how we have got this notion of a Time that can be measured with clocks and rabbits, but not with frogs.

We all have a pretty good idea of what we mean by Time, whatever the metaphysical difficulties, and neither children nor savages need clocks to tell them when they are hungry or sleepy. Early intelligent Man must soon have noticed that many physical events are regular in time, and that they record its passage more reliably than does human memory. But Kant gives weighty authority to the opinion that the concept of time is not an empirical one derived from any experience, but is given *a priori* as the necessary presupposition for the perception of co-existence and succession in the external world.

Early Man must have seen that the length of the day and of the year were constant, but he will have reached that conclusion by comparing them with his own inborn time sense, and not the other way round. Not all physical events are regular in time, and no one would have had much use for a calendar depending on showers of rain, for instance. The conclusion that the movements of the sun are regular in time, and the weather is not, is an *a priori* one that presupposes some sense of time by which the regularity of the events can be judged. We are ready to correct sundials and clocks when they fail to agree with a better standard such as the speed of light, but that is preferred because it agrees with our inborn idea of what time is, and that is the ultimate test.

If there is such an *a priori* sense of time it must come from metabolic processes in the brain and, in Man, these occur at a constant rate with reference to the physical events which give us a measure of the passage of time. But that is so only because we are homoiothermic, or warm-blooded, and keep our bodies at a constant temperature. Since metabolic processes are temperature dependent, human nerve metabolism proceeds at a constant rate compared with external physical events, and so these will agree with our sense of time. But, according to Kant, the ultimate standard by which we judge the regularity of events in time is our inborn time sense, and so it looks as though we conclude that physical events are regular because they agree with our

„Die Zeit ist kein empirischer Begriff, der irgend von einer Erfahrung abgezogen worden. Denn das Zugleichsein oder Aufeinanderfolgen würde selbst nicht in die Wahrnehmung kommen, wenn die Vorstellung der Zeit nicht *a priori* zum Grunde läge.“

Immanuel Kant

Critique of Pure Reason  
(Trans. Aesthet., II: 2)

time sense, rather than the other way round, and this is so only because our body temperature is kept constant throughout life.

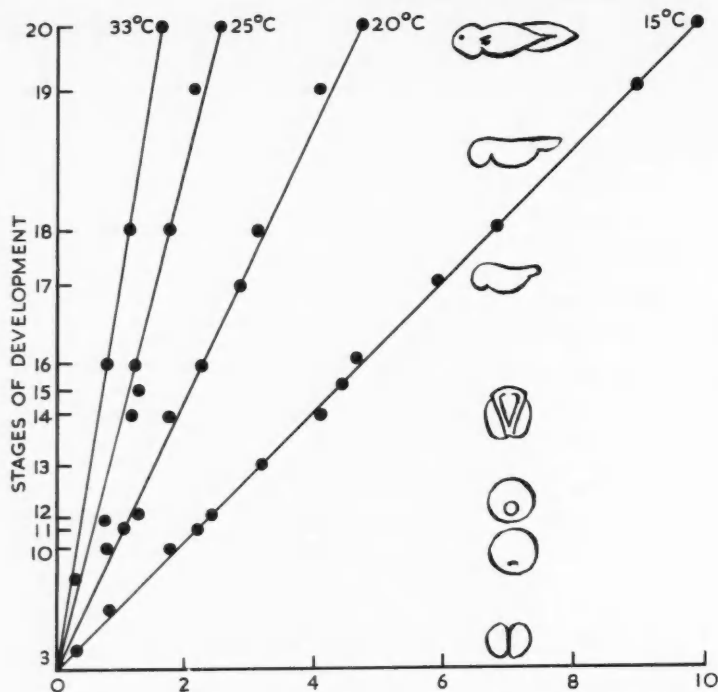
## WARM- AND COLD-BLOODED TIME

But homoiothermic animals are in a small minority and the vast majority of living creatures are poikilothermic, or cold-blooded, and their temperatures fluctuate with that of the outside world. Lizards darting about in the sun with extraordinary speed are a familiar sight, but in chilly weather they become quite sluggish. To us a cold-blooded lizard seems rigidly tied to its environment, unlike ourselves, but the lizard would not agree. His sense of time is inborn, like ours, and depends on temperature-controlled metabolic processes in his brain; but, as his temperature is not kept constant, physical events, which to us seem constant in time, will be most inconstant to him. But he will not conclude that his sense of time is at fault, just because the pendulum swing does not agree with it, if for him, as for Kant, the concept of time is derived from no experience but is given *a priori*.

An intelligent lizard would realise that the movements of the sun do not measure what he calls time, though they do conform to certain rules in "lizard time". For instance, as the sun rises its rate of rising falls, and as it sets its rate of setting rises; we, of course, would say that the lizard's metabolism, and so his time sense, goes faster at the higher temperature of midday. The lizard may notice also that warm-blooded animals are rather rigidly tied to the physical environment, and have to obey the laws that control the sun in "lizard time", so that in chilly weather they dart about with extraordinary speed, but in the hot sun they are quite sluggish. So no lizard would agree that the sun or a pendulum are of any use to him to measure time, for to him they are highly irregular, just as the weather is to us. But the lizard has other quite satisfactory objective measures of cold-blooded "lizard time" in his heart-beat, or when he feels hungry for the next meal, or reaches old age. He can also construct clocks that will accurately measure this cold-blooded time, relying upon temperature-dependent rates of chemical reaction, for example, or diffusion or evaporation. These chemical clocks may be less easy to read than our physical ones but they will agree with the lizard's idea of time and he will certainly prefer them to pendulum clocks or sundials, which do not. We would not think a rain gauge a satisfactory clock, though it is easier to read than a sundial.

## PHYSIOLOGICAL AGE

The embryological development of the frog shows rather strikingly how the biological time scale of a cold-blooded animal is not tied to that of the physical world.



Development of the frog *Rana clamitans* Latr. at different temperatures. (After J. A. Moore, *Ecology*, 1940, vol. 20, p. 466, redrawn and modified.)

Its development can be divided into twenty recognisable stages between the uncleaved egg and the tadpole ready to hatch. The illustration shows these stages for a frog, plotted against time at four different temperatures, and it will be seen that, within this normal temperature range, the tadpole hatches less than two days after fertilisation at 33°C compared with ten days at 15°C. So it is quite meaningless to talk of a two-day frog embryo in the way we speak of a nine-month baby, for the frog could be anything between a spherical egg beginning to gastrulate and a young tadpole swimming about, both of the same chronological age. You have to specify its "stage", which is its age in cold-blooded "frog time", rather than its age in physical clock time which happens also to be human biological time. This biological time for embryonic development can be accurately and objectively measured by a warm-blooded embryologist. Experiments can be done in which a part of an embryo is removed and incubated at a different temperature before being grafted back to give an individual with one part of its own body older in biological time than the rest, and the biological ages of graft and host can be measured by control embryos of identical age incubated with them, which act as "biological clocks". The "clock" at the higher temperature runs ahead, and when the graft is put back you can say how much older it is than the host in stages of development, which are units of biological but not of physical time; graft and host are from the same individual so their chronological ages remain the same, whatever their physiological stages of development.

#### COLD-BLOODED PHYSICISTS

So cold-blooded creatures can be thought of as living in a biological time frame which is not that of the physical world, though for warm-blooded animals the biological and physical time-scales do always coincide. To a man the "biological time" of a frog may seem somehow analogous to human time, but by Time, unqualified, we mean our warm-blooded biological time, which happens to be physical time as well. A cold-blooded physicist would have a similar absolute standard for what he meant by Time in his own biological time which is, however, not the time scale of the world of physics. He would discover that physical events occur in a time frame which is regular, though not the same as his; he would have to invent sundials and pendulum clocks to measure this "physical time", but he need not doubt that his inborn cold-blooded sense of time was the real absolute standard for Time, unqualified. He might think of "physical time" as being somehow analogous to cold-blooded time and a useful concept in physics, just as a warm-blooded biologist finds the concept of "biological time" useful when considering the physiology of cold-blooded animals.

The world of such a cold-blooded physicist would, of course, be the same world as ours with the same physical and biological objects, but the laws of nature governing their reactions would not be the same as they are for us, since time relations would be different. But, since both warm-blooded and cold-blooded time have the one essential characteristic of Time in the unidirectional before-after succession of events, the cold-blooded

physicist which would frame. Time from might be convenient physicist.

#### ASTRO

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physicist should be able to arrive at a theory of relativity which would be consistent within its own cold-blooded time frame. That would not be the same as the warm-blooded time frame presupposed by Einstein, as by Kant, but it might be none the less valid, though it would be less convenient than our own, even for a cold-blooded physicist.

### ASTRONAUTICAL FROGS

To the cold-blooded physicist, however, the relativistic problems and paradoxes of astronautics, which perplex Profs. Dingle, Fisher, and McCrea (DISCOVERY, February and April 1957, vol. 18, pp. 56, 174) would be quite familiar as part of his ordinary everyday experience. He would not be at all surprised to find that Sir Ronald Fisher's young lady, after her space trip, should have aged only nineteen years, while 290 had passed on the Earth. Such experiences are familiar to any frog who goes from a sunny pool to an icy stream and finds himself physiologically younger on his return than those who stayed behind. He can confirm that time for him really has gone slower by counting his heart-beats by comparison with those of his senile twins in their warm pool. Sir Ronald's young lady took with her a beautiful Caesium clock, and Prof. McCrea agrees that it, as well as her body, will have recorded the passage of only nineteen years. But it is the young lady's nineteen-year-old body that really interests Sir Ronald, not her clock, and Prof. McCrea has not asked us to believe that she would have aged prematurely during these nineteen years, to match her contemporaries on the Earth. If he had, and had claimed that nevertheless her journey had really only lasted nineteen years, because the clock said so, we might have asked him why he was so sure that a Caesium clock could never go wrong, even in a space-ship. The young lady's physiological ageing is our ultimate standard for judging the passage of time, and it is the claim that she would age only nineteen years, while 290 had gone by on the Earth, that is so striking.

Although the cold-blooded physicist might find physics more difficult than we do, in astronautics he would have important advantages compared with ourselves. The warm-blooded astronaut faces insuperable problems in attempting really serious extra-galactic space travel, for if his journey is to last for centuries he cannot hope to live to see its end. The cold-blooded astronaut has a simple answer to that, for he can hibernate during the journey, and perhaps even survive cooled down to the temperature of outer space. The rate of physical events in cold-blooded time is proportional to temperature, so the frog astronaut will keep his cabin warm when he starts, to keep down the speed of his craft in "frog time" while he sets his course. He will then open up the insulation and as he gets frozen stiff his speed, in "frog time", will accelerate towards infinity. When he reaches his destination and his cabin is warmed up he will revive, one heart-beat older in "frog-time" than when he fell asleep, and when he calculates how many million light-years he has travelled he will be satisfied that his velocity really must have been almost infinite. If humans are to practise astronautics on this

scale they must copy the frog and go into a hypothermic sleep for the journey. This is not inconceivably impossible, for some mammals can become poikilothermic when hibernating, and even human tissues can survive very low temperatures. If such a hypothermic man were to accompany our frog astronaut he might keep his warm-blooded ideas of time and deny that he had travelled with near-infinite velocity, preferring to say that his life had been prolonged in time, even though he had no direct experience of the passage of time while he was asleep. But the frog could retort that his human colleague was ignoring the facts of experience to suit his preconceived notion that physical, and not biological, time was the absolute standard of reference; and the man could not deny that his biological time had stood as still as the frog's during their trip, so that in biological time, at any rate, their velocity had approached infinity. To say that the speed of light in the Einsteinian universe provided an external standard of time is to beg the question, for in "frog relativity" the speed of light is near infinity throughout most of space but is slower near its sources in the stars, obeying an inverse square law analogous to gravity. In "physical time", of course, this is not so, but when a frog speaks of Time he means cold-blooded biological time, and his human companion forgets that during their astronautical adventure his biological time frame has been a cold-blooded one, which is not that of the physical world.

### CONCLUSION

All this may seem nonsense to a human physicist who can get nowhere without assuming that the things he studies are part of an objective external world, existing in a time frame. Our warm-blooded time scale, which happens to be the same as that of the world of physics, is both valid and convenient, but it may not be the only valid one that can be imagined. Whether or not the relativity theory and physics of a cold-blooded physicist would be as fundamentally different from our own as his ordinary everyday outlook on the physical world would have to be, it looks as though he could arrive at a consistent relativity theory, using his own biological time, which would be as valid as our own, if somewhat less convenient. Warm-blooded physicists have much to be thankful for that they do not have to face these problems, but they should remember that this may be so only because their inborn biological time sense corresponds with the time scale of the physical world, and that is the result of the fortunate physiological accident that Man happens to have developed homiothermy in the course of his evolution.

All these arguments have been developed from the proposition that the concept of time must be *a priori* and inborn, depending ultimately upon the metabolic activity of the brain. If some of the conclusions seem contrary to common sense, it may be that Kant was mistaken, and that the concept of time is wholly empirical and derived from experience. But that view, also, is not without its difficulties, and Prof. Bondi has warned us that common sense is an unreliable guide in matters outside common experience.

# GRAVITATION: COSMOS AND ATOMIC PARTICLES

S. TOLANSKY, F.R.S.

Professor of Physics, Royal Holloway College, Surrey

A verbatim report\* of an international conference held in January 1957 at Chapel Hill, North Carolina, U.S.A., is given in the document, ASTIA, AD 118180. The conference was attended by fifty of the leading theoreticians in the fields of cosmology, relativity, and quantum physics. Three broad aspects were under consideration: (1) unquantised general relativity, (2) associated cosmological problems, (3) quantised general relativity. The conference was opened by Prof. Wheeler who summed up the present position of classical relativity, putting in correct perspective its successes in accounting for observational data in astronomy and indicating also outstanding problems.

Throughout the conference the basic question of the relationship between electrodynamics and gravitation was clearly uppermost. Very early on it became evident that what is principally lacking today in gravitational physics is *not* gravitational theory but the absence of adequate precision *experimental* data to settle conflicting theories. Two major problems precipitated much discussion. Firstly, the obvious one of the role of gravitation in the cosmos; and secondly, the less obvious but possibly equally important problem of the role of gravitation in relation to fundamental atomic particles and their behaviour. For instance, the intriguing properties of anti-matter in a gravitational field were under some discussion. It was asked whether anti-protons and anti-neutrons would or would not fall in a gravitational field. (Possibly it is this aspect which is encouraging atomic energy specialists to keep a weather eye on gravitation problems.)

Indeed Prof. Bondi showed that according to the basic general relativity theories there is no reason at all why masses should not be negative as well as positive. According to this theory the negative mass repels all masses while the positive mass attracts all masses. (Incidentally, a system consisting of one mass of each type would uniformly accelerate.) These curious properties have been derived as an exact solution of the field equations and appear to be very meaningful for the future, especially when one recalls the way in which correspondingly obscure formulations by Dirac and Yukawa, respectively, predicted the positron and the meson. Clearly one can envisage the possibility of an anti-hydrogen consisting of an anti-proton for nucleus and a positron in its outer orbit. If such anti-matter is indeed repelled by ordinary matter then it would have *negative weight*, with startling consequences in that the

space-fiction-writer's dream of neutralising gravity becomes a possibility.

It is incidentally of considerable interest to recall that fifty-six years ago H. G. Wells, in his scientific fantasy novel *The First Men in the Moon*, invented the concept of a material he called *Cavorite*, which was opaque to gravitational forces. Acting as an absorbing screen of (as he put it) gravitational "radiation", it enabled the intrepid astronauts to cut off the Earth's gravity and fly off at a tangent—ultimately to land on the Moon.

This charmingly fanciful concept of a gravity-neutralising screen or filter, interesting as it may be, differs entirely from the concept of *negative weight* under discussion here. For *negative weight* involves an active repelling mechanism, not a mere passive cut-out, as Wells conjectured.

There was an obvious and important element of conflict in the conference, which occupied a considerable fraction of the time available. This concerned the question of the existence of gravitational waves. Although its discussion stimulated much competitive argument between two major camps (the quantisers and the non-quantisers), the position at the end of the debate was very much the same as at the beginning. Again and again the absence of decisive experiments was deplored, for indeed no one has yet devised an experiment which can detect such waves, if they exist. An answer either way would be invaluable, for it is crucial to several theories. We must wait, however, for some new fundamental ideas in experimentation (as fundamental, say, as the celebrated Michelson-Morley experiment). In any event, experimental data of very great precision will be called for to settle the second-order differences that the variety of theories predict.

Those who favoured quantisation were much concerned with obscure topological models, a bewildering field of study, most difficult to understand even with crude analogies. It is almost as if some form of obscurantism were emerging here, with concepts which appear to depart from normal physical meaning. This does not necessarily matter. That the concept of negative energy was difficult to interpret did not prevent it leading to the prediction of the positron. It may be that the very obscure new concepts in relativity will also lead to fundamentals. Prof. Wheeler outlined five new concepts already emerged or emerging as a result of pushing general relativity ideas to the limit. These are, briefly: (1) electromagnetism *without* electromagnetism, according to which one can tell about the electromagnetic field purely by looking at the metric. (2) Mass *without* mass, involving the concept of geons, which may be electromagnetic, neutrino, or pure gravitational

\* Obtainable from ASTIA Document Service Center, Knott Building, Dayton 2, Ohio, U.S.A. Papers from the Chapel Hill Conference form the bulk of *Reviews of Modern Physics*, 1957, Vol. 29, No. 3.

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radiation. Of course as yet no one has found a geon. (3) Charge *without* charge, a concept which can be described by analogy in terms of topological "wormholes". Such wormholes behave as sources or sinks of electric lines of force, yet no charge is involved. The theory implies that these wormholes are minute compared with the  $10^{-13}$  cm. dimension of a nucleon, indeed the theory gives the wormhole size as a mere  $10^{-33}$  cm., an order of magnitude much smaller than anything yet met with in atomic phenomena. (4) Spin *without* spin and finally (5) elementary particles *without* elementary particles. It was admitted that so far the "tortured scientist" has not even produced anything remotely plausible for items (4) and (5). There appears to be an element of grim humour in this when one considers that items (1), (2), and (3) are regarded by speculators in theoretical physics as plausible by contrast!

What certainly emerges only too clearly from the report was the extremely formidable nature of the problems and their fundamental character. Indeed, so far are the problems from being solved, they are not yet even completely formulated *as* problems to be tackled. The discussions led to the crystallising of a few narrow lines of attack for the future. Prof. Bergman postulated the following specifically as needing immediate attention: (1) interaction of the gravitational field with fermions, (2) interaction of gravitational with other quantised fields, (3) relation of elementary particles to unitary field theories, and (4) relation of conservation of energy and momentum to other strong conservative laws of physics. Judged from this verbatim report, it is clear that this conference achieved much of value.

The document is a notable contribution to fundamental physics.

## NOBEL PRIZES FOR 1957 AND ATOMS FOR PEACE AWARD

Less than a year ago (DISCOVERY, March 1957, p. 89) we urged that Nobel Prizes should be awarded to young research workers. Nobel himself, when naming the conditions for the awards, hoped that his prizes would go to research workers who "are on the very threshold of a great discovery in physics, chemistry, or medicine, but lacking the means to achieve it". This editorial was widely quoted in the Swedish Press and extracts from these comments were published in DISCOVERY (May 1957, p. 212). It is therefore with very great pleasure that we see the Nobel Prize for Physics going to two outstanding Sino-American research scientists, Dr Tsung Dao-lee who is thirty-one and is now an Assistant Professor at Columbia University, and Dr Chen Ning-yang who is thirty-

five and working at the Institute for Advanced studies at Princeton.

### Physics

Doctors Chen and Tsung are, of course, well known for their research work on the failure of the parity law (DISCOVERY, April 1957, p. 138). This fundamental law, long known in molecular and atomic physics, stated that spiral molecules existed in both left-handed and right-handed forms; this symmetry is called the parity law by physicists. However, in the last five years it has been found that this is not so, and it is due to the experimental work of Drs Chen and Tsung that this law has been questioned. The physical cause for this discrepancy is not yet clear, but confirmation of their early

work has now been obtained both in this country by Prof. A. Salam of the Imperial College of London, and by Prof. Landau in the Soviet Union.



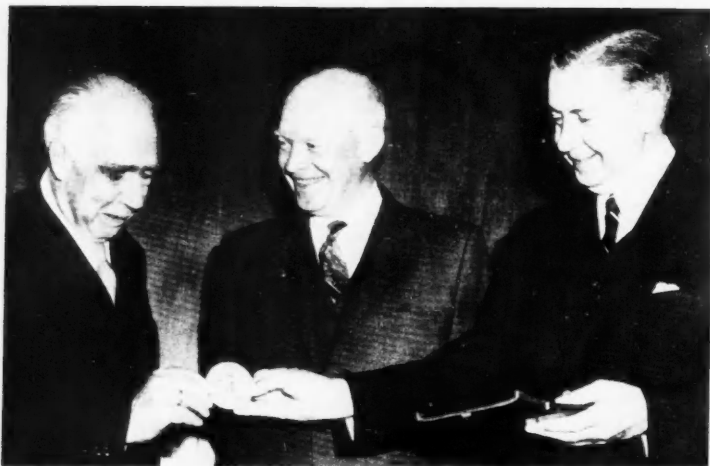
Sir Alexander Todd, F.R.S.

### Chemistry

The Award of the Nobel Prize to Sir Alexander Todd, F.R.S., Professor of Organic Chemistry at the University of Cambridge, and a Fellow of Christ's College will be warmly welcomed by all. Sir Alexander is not only well known for his many brilliant chemical achievements, but also as Chairman of the Advisory Council on Scientific Policy for H.M. Government since 1952. Many honours have been bestowed on him from chemical societies and scientific bodies in this country and overseas.



Dr and Mrs Chen Ning-yang (left) and Dr and Mrs Tsung Dao-lee (right) pose for pictures with their children in the grounds of the Institute for Advanced Study at Princeton, N.J., after the two scientists were named as recipients of the Nobel Prize for Physics. The children are (from left) Dr Chen's son, Franklin, 6; James, 5, and Stephen, 2, sons of Dr Tsung.



Dr Niels Bohr (left) seventy-two-year-old Danish physicist, is presented with a medallion at the National Academy of Sciences as he receives the first \$75,000 Atoms for Peace Award. President Eisenhower looks on as he attends the ceremony. Presenting the medallion is James Killian, Jr., President of Massachusetts Institute of Technology and Chairman of the Awards Committee Board of Trustees. Dr. J. Killian was recently appointed by President Eisenhower as special co-ordinator of, and adviser on, scientific matters.

His early chemical work was concerned with the synthesis of aneurin (vitamin B<sub>12</sub>) and this is now the basis of the commercial production of this compound. In the field of nucleic acids, perhaps, Sir Alexander has been most outstanding. He synthesised two completely new substances, adenosine diphosphate and adenosine triphosphate; these are thought to be of vital importance in making energy available to living organisms and in the work of the muscles. There can be little doubt that his contributions in this field should have made Sir Alexander a recipient of the Nobel Prize long ago.

#### Physiology and Medicine

Dr Daniel Bovet, head of the Istituto Superiore di Sanità in Rome, has been awarded the Nobel Prize for Physiology and Medicine. The Prize was for his discoveries relating to the production of a synthetic form of curare. The drug, in its synthetic form, inhibits the action of certain body substances, in particular, their action of the vascular system and the skeletal muscles.

Dr Bovet's discoveries are of particular importance to surgery, for relaxation of the muscles is essential for surgical operations, and the use of synthetic curare permits adequate relaxation with a much smaller dose of anaesthetic. His experiments with curare are subsequent to his pioneer work with antihistamines twenty years ago. He is reported to be working, at present, for a cure of asthma and migraine.

Dr Bovet was born in Neuchâtel, Switzerland, but is now a naturalised Italian. He studied science in Geneva

and later transferred his scientific activity to the Pasteur Institute in Paris; in 1936 he became head of the laboratory for therapeutical chemistry. In 1947 he took up his present post in Rome.

#### Atoms for Peace Award

An Atoms for Peace Award has been given to Dr Niels Bohr, Professor of Theoretical Physics at Copenhagen University. The Award carries with it a grant of approximately £26,785 (\$75,000), and a medal. This was the first of ten Awards to be presented over the next ten years by the Ford Motor Fund who created them in response to an appeal from President Eisenhower at Geneva, 1955. In calling for a renewed

international effort in the harnessing of nuclear science to peaceful uses, President Eisenhower had expressed the hope that "private business and professional men throughout the world will take an interest and provide an incentive in finding new ways that this new science can be used . . . for the benefit of mankind and not destruction".

Dr Bohr was awarded the Nobel Prize for Physics in 1922. He had been appointed to the chair of theoretical physics at the University of Copenhagen in 1916, and on his initiative the Institute for Theoretical Physics was opened there. The Institute was founded to give an opportunity for the closest possible connexion between theoretical and experimental researches in atomic physics. International conferences were held for the exchange of scientific information. The Institute became a haven for scientists forced to leave their countries during the war, and after the war continued to be a focal point for atomic physicists all over the world. Dr Bohr, its Director, urged his colleagues and students to press forward in an endeavour to realise the "great promise" atomic power holds for the progress of civilisation.

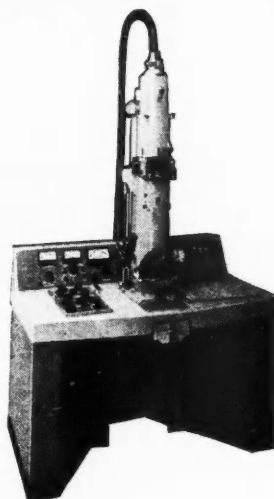
In 1952 the Institute was selected as the temporary location for the theoretical group of CERN, the European Organisation for Nuclear Research. Dr Bohr was an early advocate of this collaborative effort of twelve nations, for he believed that the responsibility for applying the advances in atomic science to peaceful rather than warlike uses rests with all people of all nations. CERN's activity continued under Dr Bohr's direction until 1954 and was housed at the Institute until 1956.

In 1955 the Danish Government established an Atomic Energy Commission to study the utilisation of atomic energy for scientific and industrial purposes and appointed Dr Bohr as its chairman.



Dr E. B. Chain of Great Britain (right) congratulates Dr Daniel Bovet of Italy (left) after the announcement that Dr Bovet had won the Prize for Physiology and Medicine. They are shown here at the Istituto Superiore di Sanità in Rome, Italy. Dr Chain won the Nobel Prize for Medicine in 1945.

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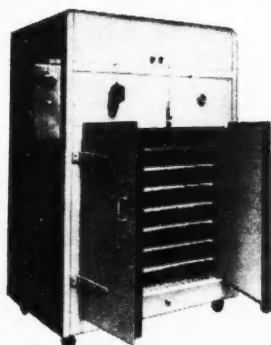
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# THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

This photograph of the first Soviet earth satellite was taken through a 25-inch telescope at the Australian Commonwealth observatory, Mount Stromlo, near Canberra, on the night of October 8. The background was exposed first for about five minutes, then the plate was exposed a second time when the satellite appeared. The white line shows its tracks during five seconds. The picture was taken by Dr Kurt Gottlieb, the observatory's research officer.

*Barely had we sorted the preliminary material on Sputnik I when a second Soviet satellite, weighing more than half a ton and carrying a dog passenger had been placed 1000 miles up in the sky. It was launched on the morning of November 3.*

## Tracking the Satellite

Although the Russians never revealed the launching site of their satellite, calculations elsewhere gave it as somewhere north of the Caspian. The launching time is calculated at about 9 p.m. (GMT), October 4.

The signals were first picked up in Britain shortly after midnight by the BBC listening post, at Tatsfield, which reported clear reception on both frequencies. Within a few hours a number of other stations in Britain were tracking the satellite by radio. Their observations were continued until, on the following Tuesday, October 8, a fault in the keying mechanism of the transmitter developed and the 20-megacycle frequency went off the air. For more than twelve hours the transmitter was operating on the 40-megacycle frequency only, giving a regularly intermittent signal. Later the 20-megacycle signal reappeared sporadically but it was nearly a week before the mechanism

which interleaved the transmission of one frequency with the other appeared to have freed itself completely.

The signals transmitted on both frequencies became noticeably weaker from the end of the second week. Also they were transmitting continuously on both wavelengths which made them difficult to observe. On Saturday, October 26, the signals ceased for good when the batteries gave out. Russian forecasts had given an estimate of a fortnight; the batteries had in fact lasted three weeks. Once the signals had failed, however, most countries had to rely on visual observations for tracking the satellite where previously they could depend on radio observations. Having already shown themselves to excel in the technique of radio observation, the British counted themselves fortunate also in having the only instrument in the world capable of locating the satellite or its rocket by any other means. The Jodrell Bank giant radio telescope, operating as a supersensitive radar set, will prove particularly valuable in tracing the end of the satellite and its accompanying rocket.

## Rocket Survives Longer than Expected

After American radar had picked up an object trailing the first artificial satellite,

the Russians identified it as the launching rocket. The Russian announcement came two or three days after the launching, by which time the rocket was some distance behind the satellite. Despite prognostications of a short life for the rocket-case from several eminent western scientists it remained in orbit for over a month, surviving two major meteor showers, the Orionids and the Giacobinids. By this time the rocket had completed more than 300 revolutions.

There was evidence, however, that the ellipse of the orbit was altering relatively rapidly from quite early days; apogee was coming in from the first week and thereby reducing the mean orbital distance and the period. Ten days after launching, the rocket was as far ahead of the satellite as it had previously been behind. Towards the end of the third week it had lapped the satellite once, and was eighty minutes ahead of it on October 26. Of course, the rocket's orbit, by this time, was below that of the satellite for most of its journey.

The contrast in behaviour of rocket-case and satellite suggested that there was considerable difference in their density (the greater weight of the satellite being in its favour). The

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Russians have reported the overall weight of the satellite as 184 lb., though its case was said to be of aluminium. They also suggested that although the satellite is expected to burn up as it falls through the atmosphere, the rocket-case, which is made of harder material, may not disintegrate completely under atmospheric friction before falling to Earth.

During the early part of its life the rocket was the brighter visual object; sightings and photographs were of this and not, as at first claimed, of the satellite.

#### Atmosphere is Thinner and Colder

The modulation of radio signals from *Sputnik I* delivered information on temperature at orbital heights and thence by extrapolation on pressure and density, to Soviet listening posts. The Russians, though not revealing the values associated with the modulations, declared that they had in this way learnt that the "atmosphere" through which the satellite was flying was much rarer and the temperature much colder than previously supposed. These findings tallied with the lack of drag suffered by the satellite, and its extended lifetime.

An article in the Soviet technical journal *Radio* for June, contained a diagram of a typical modulation of the double-frequency transmission.

#### Russian and Other Observing Posts

The regular satellite-tracking network in Russia seems to have consisted of sixty-six optical observatories led by the Pulkova Observatory, near Leningrad, at which an assembly of thirty specially developed satellite telescopes had been set up. The main radio-tracking in Russia was carried out by twenty-six Russian observation posts, operated by the DOSAAF (the Voluntary Society for

Assistance to the Armed Forces, a kind of Observer Corps). These posts were equipped specially for the job but radio-tracking seems to have depended heavily on a standard direction-finding technique for which a special attachment was available. Doppler calculations were also used.

On the whole it appears that the Russians have relied principally on visual observations to keep track on both satellite and orbiting rocket. This puts the observers at a certain disadvantage in two respects; the objects are only visible at dawn and dusk, and even then observations depend on fair weather. The facts that a request was made on October 26 by the Soviet Astronomical Union to Prof. Lovell to locate the rocket by radar, and that the position given by the Russians was not accurate suggest that the system was not wholly reliable. It was also revealed that satellite observations were carried out from Soviet Arctic drifting stations, and also in the Antarctic. The latter are important because of geomagnetic data that can be derived from them.

#### Increasing British Observations

Members of the Satellite Sub-committee of the British National Committee for the IGY, at a meeting held soon after the launching of the first Russian satellite, decided to set up several additional working parties with the object of formulating a programme which could be carried out from this country at a later date.

The group wasted no time in fulfilling its task of making recommendations concerning work which could be done by radio amateurs, and forming an organisation to supervise activities and collect the data. It was arranged that the radio section of the British Astronomical Association should look after

the more complex observations which required team-work and expensive equipment. Such measurements as of the Doppler shift of frequency for computing an orbit during the first days of a satellite's life, and of the Faraday effect would come under the BAA. Mr J. Heywood would be co-ordinator for this body and this type of observation should be sent to him at Norwood Technical College, S.E.

Simpler measurements such as those of signal strength would be co-ordinated by Mr G. Stone of the Radio Society of Great Britain, New Ruskin House, Little Russell Street, W.C.1. A particularly satisfactory observation for amateurs working on their own with only simple equipment was that for bursts of faint signals at other times than at times of transit. These signals (as described elsewhere in this column) are of great interest for propagation studies and they can only be detected by the human ear. No equipment is sensitive enough to pick out the faint signals from the loud background "noise"; the ear is able to do this, however.

#### *Sputnik I* Helps Ionospheric Studies

From the point of view of ionospheric studies *Sputnik I* proved most rewarding as long as its radio transmitter was working. The chosen wavelengths combined with its operating heights afforded an opportunity for a fine experiment. It was as if a radio transmitter was being dipped in and out of the other side of the ionosphere, as Mr Martin Ryle of the Mullard Radio Observatory put it. As a consequence the measurements of a number of different factors was made possible, and at least six radio groups in Britain made the most of it. These included the Radio Research Station, Slough; the Royal Aircraft Establishment, Farn-



Soviet students follow flight of satellite. Members of a class in astrosiences at the Goedesy Institute in Novosibirsk, Siberia, watch the flight of the Soviet earth satellite through special reflection telescopes, on October 7, signalling telegraphically the length of their view.

borough; the Royal Radar Establishment, Malvern; the Signals Research and Development Establishment, Christchurch, as well as the Cambridge and Jodrell Bank scientists.

By means of the study of the Faraday effect, electron densities at orbital heights were calculated. The Cavendish radio astronomy group at Cambridge took a leading part in this work. The Faraday effect depends on the rotation of the plane of polarised radiation on passage through an ionised medium in the presence of a magnetic field (such as obtains in the ionosphere). If the field is assumed to be constant the angle of rotation is determined by the total number of electrons along the line of sight. (Rotation was observable as a regular fluctuation of signal intensity.)

Through the maintenance of a continuous patrol on the satellite's signal strength, valuable data on the long-distance propagation of radio waves was obtained. It was of great interest to find that bursts of signals sometimes occurred when their source was on the other side of the Earth. This would depend on different properties of the ionosphere in different localities, acting in some places as a mirror and sometimes as a lens. One recurring effect observed several times on 40 megacycles at about 3 p.m. was of especial interest: the signal burst was picked up at Farnborough although the satellite was at that time passing over India.

There is no doubt that ionospheric physicists are more than content with

the 20- and 40-megacycle frequencies for the satellite and prefer these to the 108-megacycle frequency chosen by the Americans. There is every reason to believe, however, that at least for the time being the Russians will continue to use the two lower frequencies. At the Washington satellite conference in the beginning of October, the Russians expressed themselves prepared to try out the 108-megacycle range if the Americans cared to let them have a suitable transmitter. It therefore appears that they do not at present have any 108-megacycle equipment ready.

During the course of this conference a recommendation was adopted to the effect that radio observatories operating on 20 and 40 megacycles should be established "in all countries". The Russians have been completely cleared of lack of good faith in not communicating the wavelengths of their first satellite in advance. It seems they attempted to pass on the information to the appropriate quarter in plenty of time but the information was not received.

#### First Experiments from Skylark

Throughout the late summer and early autumn test flights with Britain's *Skylark* sounding-rocket have been taking place at the Woomera rocket range in Australia. One of the scheduled IGY firings carrying instruments has reached, on November 13, a height of 83 miles, carrying grenades, window cartridges, pressure gauges, and equipment for

dielectric experiments. The grenade experiment is intended to estimate temperature at height and the observation of the descent of radar-reflecting foil which is designed to give data on winds up to 50 miles high. (These experiments were described in some detail in the May issue of *DISCOVERY*.) Later on it is expected that *Skylark* rockets will be launched from the rocket range at Aberporth on Cardigan Bay in Wales. Measurements from a temperate climate will then be available for comparison with the Australian data.

#### New Stations for Australia's Seismic Work

Australia is to build five seismic observation posts to enable a study to be made of movements beneath the Earth's crust, not only for the IGY but as a long-range plan. These posts will fill a gap in the seismic record that extends from the tropics of the Indian Ocean, to Antarctica. Already one of the new stations, at Port Moresby in the Australian-administered territory of Papua, has come into operation. The others are to be located at Mundaring, Western Australia, Canberra National University, Adelaide University, and at Charters Towers, North Queensland.

#### Oxygen Masks for Sovietskaya

More details have recently been released on the conditions that are to be met with at Sovietskaya, the name of the Soviet station to be located at the so-called



A team of twelve British scientists tracking the satellite at Cambridge. Here Mr Martin Ryle, F.R.S., director of the University's radio observatory, looks at a plot of the course. The notice says, "switch on and wait"—the longest wait would be 95 minutes, the time the satellite takes to circle the Earth. The Cambridge team worked all day and night to fit a new aerial that would give more accurate readings of the satellite's course. They are keeping track of the two satellites launched.

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#### Space Tr

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pole of inaccessibility in the Antarctic. Russian sources have stated the position lies at 15,000 feet above sea-level on an ice-plateau, and is more than a thousand miles from the nearest coast. The men stationed there will have to wear oxygen masks to carry out their duties in the attenuated atmosphere. It is expected that temperatures will frequently drop to 150° F of frost. It seems certain that nowhere on Earth will scientific observations be carried on under such arduous conditions.

Experience in the interior of Antarctic last season has shown the Russians that the snow-tractors previously in use though effective near the coast have got hopelessly stuck in the dry, powdery snow that sometimes lies 300 feet deep over the solid ice surface. Their power has also been reduced to about half at the high altitudes at which they are required to operate. Consequently two completely new types of snow-tractor have been designed and built in time for this year's operations. One design, the *Leader*, has caterpillar tracks over three feet wide which should overcome the conditions of soft snow. Three of these tractors, which are also equipped with powerful air-compressors to increase power at altitude, will lead the convoy

as far as Komsomolskaya, the most forward Russian station so far in regular operation and which is 550 miles from Mirny. From there onwards, much the longest part of the journey, the other type of tractor, the *Penguin*, will take over. Twelve of these have been embarked on the Antarctic relief ship *Ob* for the expedition. They are very light, powerful machines, with heated cabins equipped with instruments which should enable observations to be made while the convoy is in motion.

This year's relief party together with the new tractors and other equipment are expected in the *Ob* off Antarctica this month (December). For this year's visit south the ship has been re-equipped. She now has an installation for launching small rockets for observing the upper atmosphere work and a deep-water winch has been put in for under-water geological work.

The Russians have been passing on "know-how" about the operation of tractors in conditions of low barometric pressure to Sir Edmund Hillary and his New Zealand party who are now engaged in ferrying stores for the relief of Dr Fuchs' party to a position several hundred miles into the interior of the high polar plateau.

### Sputnik I—What the World Said

*The satellite is a hunk of iron that anyone could launch.*—Rear-Adm. Rawson Bennett, U.S. Chief of Naval Research.

*Like atomic energy, this device can serve the purpose of peace, or it can be used to blow us to bits.*—Mr Cabot Lodge, U.S. delegate to UN.

*I do hope people will not get confused into thinking this great scientific experiment has much bearing on the problems of defence. In fact it does very little for them. It solves very little of them.*—Sir Owen Wansbrough-Jones, Chief Scientist, Ministry of Supply.

*I think it is absolutely stupendous, about the biggest thing that has happened in scientific history.*—Prof. A. C. B. Lovell, F.R.S., Director of Jodrell Bank Experimental Station.

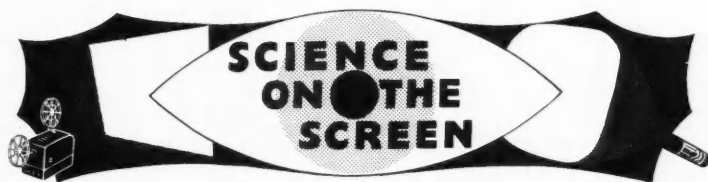
*I don't think international law applies to the Moon.*—Sir Hartley Shawcross.

*Now the bomber and fighter can go into the museum.*—Khrushchev.

*Whatever else it is, the satellite is a triumph of technical education.*—Lord Hailsham, chairman Cons. Party Org.

*Fantastic!*—Dr Joseph Kaplan, chairman, U.S. IGY Committee.

*Why isn't the RAF going up to shoot it down?*—Telephone inquiry to the Air Ministry.



### Space Travel on Television

Apart from a single programme (James McCloy's "Frontiers of Science" on October 11, BBC television), weeks have gone by without the slightest indication that either BBC or ITV have even thought of science broadcasting for adult audiences. The schools, on the contrary, were being served admirably in this respect on both wavelengths. Clearly our programme administrators must consider science is child's play! One hopefully scanned the published programmes week after week, but as far as these went an adult might well have thought he lived in a pre-scientific era.

Then, poetic justice: the news of the Russian satellite launching broke, and overnight a whole astonished world, from university professor to the variety-turn comedian, became science-conscious. By a happy coincidence the BBC "Frontiers of Science" programme, which was of course planned and published well before satellite news, had chosen as its subject *Space Travel*. A thirty-minute programme was divided into three main topics. The first, given by Sir Harold Spencer-Jones, until

lately the Astronomer Royal, dealt with the astronomical problems. The second topic, covered by Dr Baxter of the Havillands, was concerned with rocket motors; and the third topic, dealt with by a medical aviation expert from Farnborough (with the usual silly restriction as to anonymity), was devoted to the physical stresses a space aeronaut could be expected to endure.

Of course, the Russian satellite was not the real subject of the broadcast (which was built up in pre-satellite days), but it naturally dominated the whole outlook. Sir Harold, in a mere ten minutes and with the aid of magnificently large models of the Earth and Moon, explained, in a manner delightfully convincing to any layman, why a speed of 18,000 miles an hour was needed for a satellite to achieve orbital rotation, and further why 25,000 miles per hour was needed to open out such an orbit to reach the moon. With his characteristic penetration he focused attention on the most important aspects, emphasising that perhaps the most valuable thing to be learnt from a satellite rounding the Moon would be

the securing of pictures of the Moon's rear face, always to be hidden from us.

Sir Harold ventured the view that, whereas he readily envisaged reaching the Moon by rocket flight, he thought a contact with Mars or Venus to be a virtual impossibility.

The thread was then taken up by Dr Baxter, the rocket specialist, who described the formidable engineering problems of high-altitude rocketry. This section was in parts the least satisfactory of the whole. It was occasionally over-technical and was not greatly assisted by Mr. Wurmser's gallant, but on this rare occasion not very helpful, animated diagrams. For a lecturer to mention the shock pattern from a jet without further explanation is asking just a little too much from even a willing but untutored fireside scientist.

A lack of co-ordination in production was here at fault (I take it that the programme was pre-rehearsed; that is why I blame production). For while Sir Harold talked about speeds of 18,000 and 25,000 miles per hour, Dr Baxter talked about 5 and 7 miles per second. These are, of course, effectively the same, but the average puzzled listener would certainly not carry out the rapid little piece of mental arithmetic needed for conversion. Mixed-up units are bad enough in university teaching; they are fatal in popular lecturing.

Dr Baxter produced an excellent graphic illustration for indicating the

formidable size of a rocket required for a satellite, and discussed in brief the reason why nuclear energy for rocketry was not an easy solution. He predicted manned flights to the Moon before the year 2000.

The third section, clearly prepared well in advance, had no direct concern with the satellite. It was built up mainly from some exciting film sequences demonstrating what happens to a man subject to a gravitational force five times that of the Earth (5 g), and was also devoted to discussing in some considerable detail the equally important (but not so popularly recognised) physiological dangers arising in *free flight* when subject to a force of about zero g. The section ended rather lamely with an aviator demonstrating the use of a pressure suit. This was pre-built up, rather unnecessarily, with a space-fiction-writer flavour, a dangerous trap for the serious-minded space enthusiast. It made a tame finish to an exciting beginning.

But there was more to come in the last few minutes. Mr. Moore of the British Interplanetary Society (familiar to us for his regular descriptions of the sky at night on BBC television), in a short but perhaps aggressive statement, claimed that his members had made formidable contributions to the success already attained in space flight. These were not specified in detail.

There was a wind-up from Sir Edward Bullard, who, in a spirited summary, dismissed the immediate potentialities of atomic energy for rocketry, and also expressed disagreement with Sir Harold's more optimistic view of future possibilities.

With so distinguished a company, of course, the broadcast was immensely informative and authoritative. Would we had more like it as regards both content and presentation. There exists an adequate enough pool of distinguished scientists in this country, in every discipline, to enable producers to be able to put on numerous such programmes. The fault lies not with them but with the meagre time the major planners allot to science for the adult.

As in an earlier broadcast dealing with the circulation of the blood and also directed by Mr McCloy, "Space Travel" was characterised by a successful unity of subject. This was not the case in the former "Questions of Science" series, but in "Frontiers of Science", with no less than seven contributors to a mere thirty minutes, all was held nicely together by the single common subject, Mr G. J. Smith made an admirable chairman and asked the right questions at the right places.

S. TOLANSKY

#### Eleventh Congress of the ISFA

More than two hundred delegates, representing some twenty countries, were present at the XIth Congress of the International Scientific Film Association

at Amsterdam last month. Among the countries represented were the German Democratic and Federal Republics, Poland, the U.S.S.R., and the members of the Latin-American countries. A strong British delegation, led by Mrs Helen Coppen of the Institute of Education, London University, made several important contributions to the various discussions. Mrs Coppen herself presented a paper to Congress on "The Quality of Films for the Popularisation of Science", in which was discussed the evaluation of documentaries and short films. The paper was not concerned with films made for use by specialists in school or university teaching, but with films defined as popular science aimed at particular groups; for example, health films made for parents and for industrial workers, and general information films designed to give the scientific background to daily activities.

During the course of the Congress some one hundred and eighty films were shown from the member countries, including a good representation from Great Britain, which included the recent Shell film *Approaching the Speed of Sound*, shown at the gala film performance which opened the Congress, *William Harvey and the Circulation of the Blood*, and *Atomic Achievement*. Some outstanding films were screened during the medical-surgical sessions. *Brain Surgery* from Hungary, and the Czechoslovakian film dealing with the enucleation of the eye without implantation and with implantation produced by the Studio of Popular Scientific Films in Prague in 1956, were particularly outstanding.

The Russian delegation put forward an interesting suggestion during the second general assembly, namely that the International Scientific Film Association should bring its committees into line with the main directions of scientific film-making under headings like the popularisation of science, education, and research. The Council agreed to discuss this suggestion.

Among the most interesting sessions were those on modern techniques in scientific cinematography covering such important aspects of modern photographic techniques as the influence of light on living structures in cinemicrography, the comparison of the results obtained with this technique by observing the same structure under different lighting conditions (direct, indirect, phase-contrast, and interference). Zoom lenses, electronic telerecording, and practical devices for high- and low-speed recording were also discussed.

Monsieur Luc Haesaerts of Belgium was a popular choice as President of the Association for 1957-8, and it was decided that the 1958 Congress of the Association should be held in Moscow. The new Council is comprised of members of the German Democratic and Federal Republics, Australia, Austria, France, Great Britain, Italy, the Netherlands, Czechoslovakia, the U.S.S.R.,

and Uruguay. Our Netherlands hosts did much to make this Congress one of the most enjoyable yet. GORDON DAVIS

#### Films for Industry

Between October 8 and 12 a Festival of Films in the Service of Industry was held in Harrogate. This was no ordinary film festival. When industry tackles a job it can be expected that it will be a business-like affair. Harrogate was no exception; industry rolled up its sleeves and worked. It was, however, subject to the stresses and strains of public relations and manipulations since this was, after all, a competitive event. In the absence of crying starlets (either because their film had or had not been selected) and hysterical directors, it ran surprisingly smoothly for a first event, no doubt stimulated by the "moorland tang" in the air, which the Festival Programme told us to expect.

The Festival was opened by Lord Mancroft, who in a skilfully delivered address with much wit and humour, emphasised all the points which the film could do for industry. His audience was stimulated by the obvious hard work which had gone into his words. It was not, however, free from lobbying, the crudest of which was his plea that film-making should be left to the "experts" and not allowed to get into the hands of the uninitiated.

The first day's business was soon in hand with five film viewings under the subject headings: Guidance on Careers in Industry, Sales and Dealer Training, Productivity, Films for Schools, and Human Relations; and two speaking sessions under the headings of Productivity and Public Relations. Films for Guidance on Careers were relatively undistinguished save for a rather over-dramatised though technically highly polished production, "Test Flight 263", telling of the work in all fields of science which goes into the development of a new aircraft. Sales films were uniformly crude or improbable; producers it seems find it impossible to make a technically presentable sales film which remains acceptable to intelligent audiences. The Gas Council, with its series light-heartedly called "Gasmanship", made the grade. In films for use in schools figured the already well-known "Mirror in the Sky", but Unilever's "The Oil Rivers" showed its paces on economic geography without talking down to its audiences. "The Film That Never Was" received applause in the course of Films on Human Relations which completely justified the daring of its sponsors, the Ministry of Labour. "Men on the Mend", describing the Swindon Rehabilitation Centre of the British Railways, and "Hemel Hempstead", on the forthcoming removal of the Dexon factory, got nearer to the essence of the session. Productivity held sway with discussions and films in other locations. This Cinderella subject was largely beset by jargon and canniness, and only lifted

out of the rut by "Work Study—Its Application to Team Work" breaking new ground.

Public Relations, Technical and Technological Films, and again Productivity were spread over the second day's proceedings. Most of the producers rose to the opportunities provided by prestige film-making. "Pan-Tele-Tron" was memorable for its light-hearted history of telecommunications with drawings reminiscent of Douanier Rousseau; "Steel Rhythm" captured the processes of a steel plant in terms of rhythm; "Foothold in Antarctica" made the most of scanty material, while "The Twilight Forest" demonstrated craftsmanship in film-making by its excellent editing. It is a fascinating story of commercial exploitation of the West African hardwood forests. Another film, "Three Roads to Tomorrow", also dealt with West Africa, though in a diffuse and almost pointless manner. Sociologists would probably find it interesting as it shows Nigeria emerging as a nation, influenced by European and American ideas, yet consciously drawing on their cultural tradition. Films in the Technical and Technological unit were uniformly competent, yet the two films from the Shell Film Unit, "High Speed Flight" and "Forming of Metals", when seen side by side, reveal an unhappy tendency; they are showy almost to the point of being exhibitionist.

In the evening session of foreign films shown out of competition, "Your Share in Tomorrow", a film relating the benefits of the New York Stock Exchange, reduced the house to laughter by its implied speculative prophecy of the U.S. launching a satellite. The evening closed with a sobering glimpse in "The 2nd Engineering Exhibition in Brno, 1956" of Czechoslovakian competition in the world market.

The third day also was largely taken up with public relations films, which were the greatest in number of any entry. "History of the Cinema", Halas

and Batchelor's controversial and independent picture which was unacceptable to commercial distributors, turned up sponsored by Philips. "Song of the Clouds" and "Atomic Achievement" were already well known, but "Mouse-trap is Out", in spite of its gimmick title, was highly thought of. A viewing of Sales Promotion efforts produced some honest films. One which will in time be prized by sociologists was "Screenagers". This film, in combined live action and animation, was a report introduced and narrated by Dr Mark Abrams on the buying habits, which revealed the largest potential market lay with young cinema-goers, hence the title. Among the films from overseas screened was the impressive "Atoms for Peace" from the U.S.S.R. and the falsely poetic "A l'Aube d'un Monde" from France, also on atomic energy. Canada entered "Generator 4", a further epic on the Kitimat project in British Columbia. Italy, with "Some Applications of Automation at Fiat", did not rise to the subject, which remained persistently pedestrian. The U.S.A. was better represented with a fable called "Dear Mrs Calvin", a *tour de force* called "Dial S for Service", a British-made cartoon, "The Dragon Slayer", and finally the apex of technical achievement, "Milling and Smelting the Sudbury Nickel Ores".

The last day's films consisted of the left-overs, largely films in such units as Health and Safety, and Training. The timely "Criticality" from the UKAEA was highly thought of for all those in the growing industry of nuclear engineering. "Successful Instruction" was remarkable in many ways, one of which revealed the War Office as an adventurous sponsor. Intended as a primer for all those needing to give instruction, it relied on the form of a lecture given from the screen.

Almost everyone expressed themselves as satisfied with the awards, the judging for which was undertaken by

juries not normally associated with the film industry. A fact which probably accounts for the oblique nature of some of their choices, which were: Public Relations and Prestige, "Oil Harbour—Aden", "Atlantic Link"; Sales Promotion, "Introducing Telex", "Pipeline into Persia"; Training inside Industry, "Successful Instruction", "Safe Transit"; Technical and Technological films, "High Speed Flight"; Sales and Dealer Training, "Golden Minutes", "Demonstration Selling—Gasmanship"; Films for Schools, "Mirror in the Sky"; Health and Safety, "Don't be a Dummy", "Criticality"; Guidance on Careers, "Golden Future"; Productivity, "Introducing Work Study", "Think of the Future", "Mechanisation of Livestock Farming"; Human Relations, "Men on the Mend", "Hemel Hempstead".

The faults in the Festival were few but mainly traceable to its having been conceived in terms of a showcase. The organising film-makers having a vested interest in bringing in more business and the companies with their films selected showing their magnanimity. One of the biggest oversights must have been the omission of a section on Research Films in industry. This could not have been competitive, as research does not always respond to competition. It would have been a useful meeting to demonstrate the latest results, and if this Festival becomes an annual affair this must be rectified. In all events it has served to give recognition to these films and has given them a standard which before they lacked.

FRANK BAMPING

#### Films Show Nuclear Plant Construction

The building of Calder Hall nuclear power station and the fast breeder reactor at Dounreay, Caithness, presented problems of construction which had never had to be tackled before. A series of films taken during the building operations is now being made available by the United Kingdom Atomic Energy Authority to show how it was done.

## TWENTY-FIVE YEARS AGO

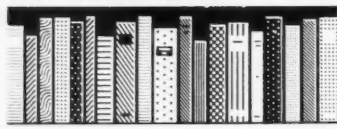
An advertisement in the December issue announced the appearance of *Television*, "the first television journal in the world". The new magazine contained, among other items, an article by Mr T. Thorne, who emphasised the importance of studio technique. "It can", he wrote, "accomplish so much for the improvement of existing television, that all physical calculations on the basis of the number of lines or areas to the square unit of surface can be entirely upset, and the eye can be made to see modelling and definition that by theory are impossible."

An editorial in *DISCOVERY*, referring to the beginning of regular television transmissions by the BBC, states: "Since the first programme in August, which opened modestly with singing and dancing, the programmes have steadily

improved. The televising of the Derby must be numbered among the accomplishments of the year, for it was the first occasion on which a daylight transmission had been successfully projected on a cinema screen to be watched by two thousand people. In America, the broadcast of sight and sound on one wave was an important step forward: an orchestra playing on the roof of a New York hotel was directed by a conductor in the studio a quarter of a mile away. Television is now attracting the attention of inventors in many countries; and in England, Mr J. L. Baird has lately perfected a new receiver in which the screen can be seen by a roomful of people at the same time."

The Baird television apparatus, as described in an article of the same issue,

was housed in a trailer caravan near the winning-post, during the televising of the Derby. "Inside was a large drum with thirty mirrors, revolved at a speed of 750 revolutions per minute, which split up the whole scene into thirty strips. A succession of images thrown by a lens on to the drum was made to move over three apertures, which admitted the different degrees of light and shade to three photo-electric cells. In this way the scene was split up into three adjacent zones and the separate signals passed by telephone to amplifiers, from whence they passed by telephone lines to the control room at Long Acre. From there they were relayed to the stage at the Metropole Cinema, and after being further amplified were passed to the receiver."



# THE BOOKSHELF

## A History of Technology

Edited by Charles Singer, E. J. Holmyard, A. R. Hall, and Trevor I. Williams (Oxford, Clarendon Press, 1956. Vol. II, *"The Mediterranean Civilisations and the Middle Ages c. 700 B.C. to c. A.D. 1500"*, ix+802 pp., 44 plates, £8 8s. net.)

Historical analysis of the past was dominated in the 19th century by attention to political and constitutional issues, to which economic history has more recently been added as a major interest. At the same time the claims of different aspects of intellectual and cultural history, especially of the history of science and of art, have been attracting a slowly increasing number of serious scholars and a growing amount of recognition within the historian's scheme of things. It is within this widening conception of the historical experience of civilisation that the significance of *A History of Technology*, of which this is the second of the five volumes to be published, may be judged. The editors, the authors, and Clarendon Press are to be congratulated on the speed with which so considerable an undertaking is being fulfilled.

The subject of Volume I was technology "from early times to the fall of the ancient empires c. 500 B.C.". The evidence on which it was based was almost entirely material recovered by archaeological excavation, mainly in the Near East. With the present volume, dealing with the technology of the Classical World and of medieval Christendom, the scope has been restricted to Europe, "for lack both of space and of writers", although medieval Arabic achievements are brought into the picture where relevant. The volume thus becomes "a survey preliminary to the account of that rising technical supremacy of western Europe which will be exhibited in later volumes". Cutting through the familiar political chronology, it draws together four main periods of largely pre-scientific Western technology, for which the evidence becomes increasingly documentary instead of archaeological: those of Hellas, heir to Minoan and to the ancient civilisations of the Near East; of Rome, responsible for a wide diffusion of techniques; of the early Middle Ages, which saw the destruction and the restoration of a measure of political and economic stability; and of the later Middle Ages, which saw the

beginnings of new technical and intellectual inventiveness in the West. The *terminus ad quem* of this volume is indicated by the title of Volume III: "The First Impact of Science on Technology c. 1450 to c. 1750."

Within this long period a number of selected topics have been treated separately in separate chapters, and the treatment is confined to technology as such, without attempting to establish any connexion with economic, social, or political history. In this sense the work provides only the materials for a more causal historical treatment, and considering the state of the subject the decision to leave it at that was certainly a wise one. As it is the volume is not only large but wonderfully rich, as a brief recitation of the subjects of its chapters will indicate. Three chapters on primary production: mining and quarrying, metallurgy, and agricultural implements, are followed by seven on manufacture: food and drink, leather, spinning and weaving, furniture, ceramics, glass and glazes, and pre-scientific industrial chemistry. Next come chapters on material civilisation: the medieval artisan, building construction, and fine metal-work; on transport: roads and travel, with a section on harbours, docks and lighthouses, vehicles and harness, and shipbuilding; and on practical mechanics and chemistry: power, machines, hydraulic engineering and sanitation, military technology, and alchemical equipment. The volume concludes with an epilogue by Dr Singer on "East and West in retrospect". It is only to be expected that some chapters should be more interesting and valuable than others, but on the whole the level is high, and although it would be possible to quarrel with some details and omissions, so much is provided that this would seem ungrateful.

The most obvious reflection that arises from reading this volume is that the study of economic and social history, of the history of science, and to a smaller extent of the history of art, must all in greater or less degree be incomplete unless the technology which provided the circumstances and possibilities of so many of the achievements in these fields is taken into consideration. Economic and social issues arise on almost every page, whether one is reading of the harnessing of the power of animals, wind and water and the medieval development of machinery for mutually converting rotary and reciprocal motion, of hydraulic engineering and the supply of water to the expanding towns, of the construction of roads, vehicles and ships, or of the mechanisation of mining and metallurgy. Reading of the chemical techniques of ceramics, glazing and painting brings the history of style and taste in art

down to practical performance. As to the history of science, the chapters on metallurgy, chemistry, and alchemy show how the craftsmen had developed apparatus, and quantitative techniques in assaying, that were to be taken over into science long afterwards. What problems, information, techniques, and apparatus did empirical technology provide for rational science in other fields, for example in dynamics and mechanics, or optics? What was the relation between technology and science in the period treated by this volume? On this we are not given much information, although perhaps something will be said in Volume III in discussing scientific instruments. In any case the characterisation of Volume II, implied by the title of Volume III, should not be taken too literally. The relations between craftsmen and scholars before the 16th century and their relative contributions to the development of science are questions that still have to be systematically investigated.

One of the most attractive features of these volumes is their illustrations. Some readers may regret the decision to redraw so many of them instead of reproducing the originals, but even so the result is pleasing as well as instructive. The volume also contains useful historical tables and maps.

A. C. CROMBIE

## Ancient Landscapes: Studies in Field Archaeology

By John Bradford (London, Bell, 297 pp., 84s.)

With thirty thousand words off the text and thirty shillings off the price, this would have been a first-class book. It sets forth clearly, though with an amplitude unnecessary to the present generation of readers, the technique of archaeological survey from the air, and proceeds to illustrate that technique by revealing examples from the Mediterranean lands. Where it errs (and let this be said at once) is in a deterring diffuseness of style in the main text and a flood of footnotes where a well-conditioned stream would have sufficed. But having said that, I have nothing but admiration to offer for a work which is scholarly, splendidly illustrated, and packed with original material and stimulating thought.

The chosen examples of aerial photography are grouped under four main heads. The first relates to a remarkable series of kraals or compounds, now visible only as soil-marks, along the Apulian seaboard. Excavation has shown that they date from the Neolithic period, but their wider context in Mediterranean prehistory can only emerge from much further research. Most of them were entirely unknown until air-photographs taken during the

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Chemical Age review of Volume IV

January 1958

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war began to reveal them with a clarity which enables them at the same time to be mapped in significant numbers and excavated with maximum economy. They were the primitive homes of farmers and perhaps fisherfolk for whom an unidentified overseas origin is postulated. Altogether, they constitute a notable addition to the prehistoric distributions of the Italian peninsula, and Mr Bradford's admirable statement of their problem will acquire more definition when the results of his trial excavations are published.

The author then turns to the cities and cemeteries of Etruria, particularly the latter, which have yielded more readily than the former to air-survey. His new plans show, in addition to the well-known mounds which have in the past yielded such a rich harvest to such summary reaping, vast numbers of additional tombs now flattened and mostly invisible on the ground. Thus integrated, the cemeteries themselves assume something of the quality of cities, with their lines of tumuli and their service-streets. Here is abundant opportunity to redeem by systematic investigation something of the evidence lost in the less enlightened past. The most important chapter, however, is that on Greek and Roman centuriation, whereby large and sometimes unsuspected portions of the Mediterranean landscape are shown to have been laid out on a grid-system for the regulation of their farming. Tunisia has long provided a classic example of this procedure, but the superb air-photographs here published from the region of Pola, the Po Valley, and Dalmatia are no less impressive, and are backed by a valuable discussion of their layout and sub-division in the light of the literary evidence. Southern France, too, previously thought to be devoid of evidence of this kind, has at last been persuaded to reveal sufficiently recognisable traces at Valence, Narbonne, and Béziers, and more reluctantly at Orange, where the familiar epigraphic fragments of a land-register have at last acquired some slight though still insufficient substance from air-photography. Of special interest is Mr Bradford's discussion of certain of the less normal and less understood standards of land-division, to which this medium is more likely than any other to lend a new clarity.

The book concludes with a miscellaneous collection of town-plans, both classical and medieval, extending from Rhodes and Melos to Castelfranco and Carcassonne, and including Ostia with its difficult harbours. These miscellaneous add less to knowledge but are well chosen as illustrations of the wide range of discovery that still awaits archaeology from the air. MORTIMER WHEELER

#### Men Against the Frozen North

By Ritchie Calder (*London, Allen and Unwin, 1957, 279 pp., 16s.*)

This book provides as good a picture

as an observant man can pick up in a few weeks of the multifarious activity which is transforming the Canadian Arctic. In the spring of 1955 Mr Calder travelled extensively in the region, and he contrived to see a great deal in a short time. He went out with trappers and prospectors; he inspected mines and oil wells; he discussed agricultural problems at the experimental farms (it was too early in the year to see much); he sampled life in Hudson's Bay Company posts and Eskimo villages; he did the RCAF Arctic Survival course at Cambridge Bay; he travelled by aircraft, helicopter, weasel, and dog sledge. He records what he saw in an interesting way and with understanding, sketching in enough historical background to each of his scenes to give it perspective.

The book is aimed at a wide public: at the young men to whom he would say "Go north". It is therefore racily written. It is also, and how could it not be, superficial, and shows signs of being hurriedly done. But it conveys well the sense of excitement and of great potentialities. On a more serious level, the main conclusion Mr Calder reaches is clearly sound: that techniques are already available or in sight which will permit man to develop this huge area as he has developed the temperate and tropical zones. The only point which one might criticise is his view that the warming-up of the Arctic, which is known to have been in progress since the first quarter of this century, is a long cycle rather than a short one. There is not enough evidence yet for either conclusion, but what there is tends to support the other one.

TERENCE ARMSTRONG

#### The Beginnings of Embryonic Development

Edited by Albert Tyler, R. C. von Borstel, and Charles B. Metz (*Washington, Publ. 48, Amer. Assoc. Adv. Sci., 1957, 400 pp., price not stated.*)

This book is based on a symposium held under the auspices of the American Association for the Advancement of Science on December 27, 1955. As is stated in the Preface, "no special attempt was made to force the contributors into a preconceived plan, or to develop an overall general concept". The result is, of course, something of a hodge-podge, but it is valuable because of the quality of the individual items. About half the contributions take the form of rather comprehensive and fully documented summaries of some topics of current importance in studies of the earliest stages of development, while the remainder are more concerned with the authors' individual researches. Among articles of the latter type, one may mention Vincent on the functions of the nucleolus in echinoderm oocyte formation, Monroy on changes in proteins, and Shaver on cytoplasmic particles, again in echino-

derm eggs, and Ranzi on his well-known studies on protein salting-out curves in a variety of species; Gregg on metabolism in arrested *Rana* hybrids, and Reverberi on enzymes in ascidian development. There are four very useful reviews of various aspects of fertilisation: Metz on sperm and egg substances, Austin and Bishop, and also Chang, on fertilisation in mammals, and the two Colwins on acrosome filament formation and sperm entry. Lehmann reviews the results of nuclear transplantation, and von Borstel gives an account of some aspects of nucleocytoplasmic interactions in early insect development, with particular emphasis on recent studies, such as those by himself and others on *Habrobracon*. Finally, Tyler discusses recent immuno-embryological studies. Since there is no unity to the work, there is little that can usefully be said about the book as a whole, but anyone interested in embryology will find in it a series of interesting summaries of the subjects dealt with and a very useful group of bibliographies.

C. H. WADDINGTON

#### A General Textbook of Entomology

By A. D. Imms, extensively revised by O. W. Richards and R. G. Davies (*London, Methuen, 9th edition, 1957, 886pp., 75s.*)

The awe-inspiring achievements of physicists have been so obvious in recent decades, that the average layman is prone to think of "science" in terms of radar and rockets. But in almost every field scientific knowledge is growing with increasing momentum. Entomology is one of the most vigorous branches of biological science, for various reasons. From the standpoint of pure science, insects are both interesting and convenient. They can be easily reared in large numbers for laboratory studies. Their short life span is an advantage to geneticists; while, in the field, their diversity of habits provides a fascinating variety of problems for the ecologist.

Apart from these academic reasons for studying insects, however, it is vitally necessary to find means of combating the vast hordes of insect pests, which constitute the last serious threat from the animal kingdom to man's well-being. The response to this challenge has been the great expansion of a relatively new profession, that is, applied entomology.

To train entomologists, a sound and comprehensive textbook is needed; furthermore, it should be sufficiently detailed to serve them in later professional life. Both "pure" and "applied" entomologists are likely to specialise on some relatively restricted group of insects, and a reference book is needed to refresh their memory of other types of insect. The textbook which has long filled this need is that of the late Dr A. D. Imms, which first appeared in 1925. Since then, there has been an

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enormous increase in entomological knowledge, which is still being added to by some 4000 books and scientific papers every year. In a series of eight editions, attempts have been made to add some of this new knowledge to Dr Imms's book. However, when I made a comparison of the penultimate (1951) edition with my own copy from student days (1930), I found comparatively little change. Pages had been added here and there giving increases of about 5% in various chapters.

It became clear to the publishers that a more drastic revision was overdue; they have been very fortunate to obtain the very competent help of Prof. O. W. Richards and the devoted labours of Mr R. G. Davies. The whole book has been most carefully revised and many sections rewritten. Many new views on insect physiology have been incorporated in the first part of the book, which has been expanded by 25%. The classification adopted is substantially similar to the original, with a few improvements; thus, some of the more diverse groups have been unpacked from the old "portmanteau" order Orthoptera and given separate status. An interesting note on phylogeny explains the insect family tree on the

basis of evolution with reference to the fossil evidence. The systematic section on exopterygota orders has been enlarged by 37% and that of the endopterygota orders by 16%. Some fifty new figures have been added and the citation of references greatly improved.

This is indeed a timely resuscitation of an old textbook. That it has been possible to revitalise it at all, is a tribute to the robust framework of Dr Imms's original textbook.

J. R. BUSVINE

### Sicily Before the Greeks

By L. Bernabò Brea (London, Thames and Hudson, 1957, 258 pp., 21s.)

This is a sound book. It is illustrated by clear line drawings and good photographs. These make visual definitions of the sites and period-names, so aiding the non-specialist reader to comprehend the material culture of early Sicily. But Prof. Brea has not been content with being up-to-date with his archaeology, he has seen it as an index of the movement of peoples. For him, and those who read his book, Sicily becomes a focal point in the Mediterranean world through which sea-borne civilisations pulsed through time. He knows the

traditions of the ancients and finds them illuminating to the archaeologist.

The story is of man in Sicily and begins rather surprisingly in the Middle Aurignacian. In Sicily this seems to have been a simple period of hunters and food gatherers. We find the Neolithic revolution sweeping from the Levant to reach Sicily and create an obsidian trade, based on the Lipari Islands. Later the metal-bringers come the same way, copper, early bronze and middle bronze, all pass through Sicily to the Iberian Peninsula and even to Britain, but a wave flows back later. Minoans and Mycenaeans trade with the Sicilian tribes, and then there is a period of barbarism when invading Ausonians and Sikels in turn drive people to live in fortified townships away from their fields. In this period we meet civilisation passing by in the ships of the Phoenician traders. Next come the first evidences of the rising Greek civilisations, and eventually the establishment of Greek cities and the full richness of iron-age culture.

The book is well conceived, and not only provides a sketch of the archaeology of Sicily, but relates it to the development of all European cultures.

C. A. BURLAND

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**A Guide to the Literature of Chemistry**

By E. J. Crane, A. M. Patterson, and E. B. Marr (New York, John Wiley and Sons Inc., 2nd edition, 1957, xiv+397 pp., \$9.50.)

One of the most regular complaints of the scientist is the difficulty that he has in trying to keep up with the ever-increasing flood of literature in his own particular subject. The chemist is perhaps better catered for than most of his colleagues in that he has available to him an extremely comprehensive and efficient abstracting service; it nevertheless remains true (though all too often forgotten) that the effective use of the chemical literature is a skill that needs just as much effort in its acquiring as does proficiency at the bench.

This book is an entirely rewritten version of the very well-known first edition of 1927; the senior author, E. J. Crane, is the Director and Editor of the *Chemical Abstracts* service of the American Chemical Society. It discusses in turn, the main sources of chemical information (books, periodicals, patents, government publications, trade literature, and so forth) describing how their contents are arranged and classified and how these sources can best be made use of. There follows a masterly chapter on the construction and use of indexes, that is itself worth the whole cost of the book. Finally, there is a section on the methods of conducting an actual search of the literature to obtain various types of information.

The writing is rather stodgy in places and some of the information provided applies almost exclusively to the United States; for example, a list of the major libraries of the U.S.A. with an indication of the chemical collections that they possess. This apart, the enormous amount of information contained in the book is of general application. There is a list of the most important scientific and technical periodicals of the world that are of interest to chemists, classified into thirty-one subject divisions, with details of the sort of coverage that they provide. The needs and interests of both academic and industrial users are catered for and no effort has been spared to make the book really comprehensive in its scope.

P. SYKES

**Living Silver**

By Burns Singer (London, Secker and Warburg, 1957, 232 pp., 25s.)

It comes as no surprise to the reader of *Living Silver* that Burns Singer's first book was one of poems. His use of words and vivid descriptive powers have been harnessed to great effect in the difficult task of making interesting and clear a wide range of facts about British fisheries and fishery biology. This is a refreshing change from the language of textbook and scientific report.

His present book takes the form of a

novel with a tenuous story which does not obtrude. In fact, his central character, Jan, is merely the means by which the reader surveys logically and willingly every phase of the industry and frequently the stages reached in research. Each important species of food fish, of prey, each type of gear and method is highlighted. Jan is also used, cleverly, to make the reader aware of doubts which exist in many fields of research—the uncertainty of interpretation—the alternative explanation of biological fact.

For the layman this is a fascinating and truly delightful study, with a wealth of detail. Sensibly, too, the word-pictures have been augmented by sketches of the fish and gear. A map and charts of fishing-grounds visited would have been an advantage, while a higher standard of accuracy in the drawings of the fish is required to do the book justice.

For the specialist reader the account provides a useful perspective of some aspects of fisheries and biological problems, which it is sometimes difficult to achieve when working in a narrow field. The references to over-fishing, however, which the reader must infer is due to removal of potential spawners, rather than the economics of fishing, will be criticised sharply and should be amended in a second impression, together with a number of editorial errors. Nevertheless, this is a valuable and eminently readable book, which layman and specialist alike can study with benefit and pleasure.

G. C. TROUT

**The Life of the Shrew**

By Peter Crowcroft (London, Max Reinhardt, 1957, 176 pp., 15s.)

There are two entirely distinct species of scientist. *Homo contemplans* and *Homo investigans* differ so profoundly in temperament and motivation, that when both colonise the same field of study, a live-and-let-live agreement is the best that can be hoped for.

In biology the representatives of the contemplative species are called "naturalists". "The Life of the Shrew" by Peter Crowcroft not only contains a store of charmingly recounted information about shrews, it also well reveals the mental and emotional lineaments of *H. contemplans* in action.

It is characteristic of each species of scientist to attribute its own standards of scientific behaviour to the other and then to rage that the standards are not adhered to. "There exists, no doubt, some great problem to do with shrews," I said to myself, as I settled down to the introductory chapter "What Shrews Are", "and Crowcroft means to solve it!"

In the chapter on "General Behaviour" my suspicions began to grow. Enraptured, I had been reading of the digging of shrews, how "if a stone is found which cannot be kicked out but is not

large enough to avoid, the shrew seizes it in its jaws, backs out of the burrow and lays it down". But quite often the shrew picks it up again and takes it somewhere else! Some shrews even heap the pebbles on their nests! What does this mean?

"I came to think," says Crowcroft, "that perhaps an animal's food-storing urge or drive was released by the presence of an object of a certain order of size in its jaws. Thus, although the animal seizes the stone for one purpose, the act of picking it up 'triggers off' actions usually associated with another!"

An intriguing problem and a good hypothesis. Now for the assault! Watch the crucial experiments being designed, the apparatus being constructed and wheeled into position! Now see the sparks fly!

It is not to be. Crowcroft reflects briefly and poetically on the "dim and mechanical little mind" of the shrew, and we are on to the next in the list of quaint antics, meticulously observed, of which the book mainly consists.

In the end, of course, it dawns on one that there is no Shrew Problem. Crowcroft just likes watching shrews. By producing this entertaining little book he has converted his private vice into a public joy, and earned the thanks of at least one humble member of *H. investigans*.

DONALD MICHIE

**Brief Notes**

H.M. Stationery Office have published *The Investigation of Atmospheric Pollution*. The report, based on observations in the year 1955, gives details of atmospheric pollution in a large number of industrial and other towns. The figures were obtained before the Clean Air Act came into force and as such will provide, with earlier data, a basis on which to assess the effect of the Act.

The British Iron and Steel Research Association has issued its Annual Report for 1956, which is available from 11 Park Lane, London.

The abbreviated proceedings of the Oxford Mathematical Conference, held at Trinity College from April 8 to 18, 1957, have been published by *Technology*, Printing House Square, London, E.C.4, at 2s. 6d.

Three recently published pamphlets on the work of the Department of Scientific and Industrial Research are: "Modern Computing Methods" (10s. 6d.), with chapters on algebraic equations and matrices, finite difference methods, ordinary and partial differential equations; "Road Research 1956" (5s. 6d.), dealing with the growing road traffic problem, accidents, protective helmets for motorcyclists, skidding, parking in London, and road materials and methods of construction; "Mechanical Engineering Research 1956" (4s.), dealing especially with fatigue strength of pin-joints, flow measurement, bearing whirl, design of extrusion dies, and heat transfer to regenerator matrices.

# FAR AND NEAR

## Schizophrenia: Major Health Problem

Schizophrenia constitutes a major public health problem in many countries of the world where schizophrenic patients occupy nearly half the space in psychiatric hospitals. This was the conclusion reached by the Study Group on Schizophrenia of the World Health Organisation (WHO) which met in Geneva from September 9 to 14 under the chairmanship of Prof. Aubrey Lewis (London). The Group, composed of twelve scientists from Germany, Sweden, Peru, Italy, Nigeria, Switzerland, Thailand, China, Great Britain, and the U.S.A., considered the problem of schizophrenia from the point of view of diagnosis, cause, treatment, and prevention.

Schizophrenia is a disease which, contrary to what was once believed, follows neither a characteristic course nor an invariably unfavourable one, says the report. The essential structure and clinical pattern of the disease shows remarkable similarity in widely separated societies all over the world; nevertheless, cultural traits colour the psychological phenomena upon which the diagnosis of schizophrenia turns. Although diagnosis is at present based on psychological characteristics alone, the Study Group held that genetic, somatic, social, and physiological causes operate in conjunction to produce schizophrenia.

Much more research is needed to obtain precise knowledge of the mechanisms of co-operation of these different factors; therefore various fields for investigation are described, in the WHO report, which stresses that "psychiatric research is not a luxury", but absolutely essential to produce advances in treatment and prevention, not only of schizophrenia but of all mental disorders.

At the present time, the Group concluded, no specific preventive measures are available to reduce the frequency of schizophrenia. However, all factors which promote good mental health may be assumed to be of use in preventing some of the manifestations of this disease.

## Rare Element

Members of the staff of the Physical Technical Institute of the Academy of Sciences of the Kazakh Soviet Socialist Republic, with the aid of spectral analysis, have found the rare element rhenium in deep layers of copper ores in the Jezkazgan deposits in central Kazakhstan.

The discovery is of great interest because it facilitates the production of rhenium for industrial purposes.

This element is a substitute for tungsten and molybdenum in making filaments for electric lamps and electro-

technical instruments. Hitherto rhenium could only be obtained from sulphurous molybdenum.

## New Safeguard Against Power Failure

J. & H. McLaren Limited of Leeds have developed a new diesel-electric unit known as RACO (rapid automatic change-over), designed for controlling generating sets in unmanned repeater stations, which are often situated in parts of the world where continuous human supervision is impracticable. The equipment acts as a safeguard against a reduction or complete failure in electric power supply.

In the field of telecommunications the control gear is designed so that any break in current supply is either less than three milliseconds or more than ten seconds. By means of their special switching system McLarens have devised a control gear which can transfer a load from one power source to another with an interruption adjustable down to two milliseconds.

In a station where no mains are available, dual or triple generating sets are installed, each with its own RACO control panel. Two sets are arranged to operate on a seventy-two-hour cycle basis. If a fault occurs on one set, the duty is transferred to the other. In triple installations a pair of sets normally shares the duty cycle with a third set used permanently as a stand-by. Under fault conditions on either of the duty sets, the operating sequence is automatically diverted to the third set.

## Nuclear Physics in Israel

An important international conference on nuclear physics was held from September 8 to 12 at the Weizmann Institute of Rehovoth (near Tel Aviv), organised under the auspices of Unesco and the International Union of Pure and Applied Physics. The conference, which brought together about 150 scientists, had as its theme "The Structure of Nuclei". The Institute of Rehovoth has become known recently for its work on the structure of the atom and on cosmic rays.

## A-Power for Australia

An aluminium industry in North Australia, using nuclear power, has been described by the Chairman of the Australian Atomic Energy Commission, Prof. Baxter, as a possible solution to the development of this vast, sparsely settled region.

Prof. Baxter said the recent discovery of extensive deposits of bauxite in North Queensland would need large supplies of electric power. Such an industry would also create new centres of population. The use of atomic

energy would make the development of inland Australia more certain. If the cost of atomic power became cheaper, as predicted, some atomic stations might be built in Australia's Eastern centres of heavy industry, alongside stations generating power from coal.

## London Exhibition Shows Dounreay Work

An exhibition which opened at 10 Carlton House Terrace, S.W.1, on November 5 showed some of the research and development work which has been undertaken by the laboratories at Dounreay.

The reactor now under construction, which will come into operation early next year, is experimental and the steps that will be taken to obtain information from it were outlined at the exhibition. Stages in the development of the fuel elements, the metallurgy and fabrication of the fuel and canning, and post-irradiation research on the fuel elements were demonstrated, as well as methods of reprocessing spent fuel to eliminate fission products and recover unused fuel and plutonium.

The use of liquid sodium at high temperatures in the heat exchange circuit presents problems of corrosion, pumping, and flow. Methods used in solving these problems were shown.

## The MIRA Torque Converter

A new torque converter, a mechanism to replace both the clutch and gearbox in a motor vehicle, has been designed at the Motor Industry Research Association's laboratories at Lindley, near Nuneaton. Based on a novel principle, the torque converter provides an infinitely variable gear ranging between the high and low gear ratios, and automatically selects the most economical gear for any road conditions. It makes possible "two pedal" car control, with no increase in weight and probably none in cost. As it continually adjusts the gear to the most economical setting, without any roughness or jerking, it should also result in fuel economy. The converter works partly by mechanical means and partly hydraulically, although, to keep power losses to a minimum, the proportion of power transmitted hydraulically is much lower than in conventional fluid drives. The forward drive mechanism consists of two epicyclic gear trains controlled by a hydraulic pump and motor assembly.

This torque converter should not be confused with the various "automatic gearboxes" which are already in use. In general these units operate with several fixed gear ratios and a means to change automatically from one to another as road and engine speeds alter.

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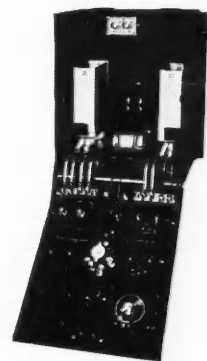
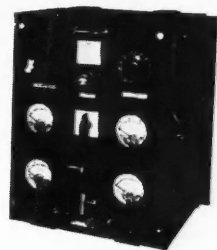
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**Power Station Driven by Sunshine**

A power plant driven by heat obtained from the sun's rays is being built in the U.S.S.R., in the Ararat Valley in Armenia, where there are up to 2600 hours of sunshine a year.

A 130-foot tower with a rotating boiler is being mounted in the middle of a large court. It is surrounded by twenty-three circles of rails. Automatic trains carrying large reflectors will run on these rails and their 1300 mirrors will direct the sun's rays to the surface of the "helio-boiler".

The sun's energy will heat the water to boiling-point and steam will be channelled to a 1200-kW turbine. The "helio-plant" will generate about 2,500,000 kWh a year.

**A Medium-range Communications Link**

By reflecting radio signals off meteor trails, a novel experimental medium-range communications link has been established between Stanford Research Institute and Montana State College, Bozeman, Montana, U.S.A. Tests have been successful in voice as well as teletype communications by the system. Preliminary studies of forward-scattering from meteor trails were performed at Stanford University. Applications have been carried out by the Institute in a research programme sponsored by the Air Force Cambridge Research Centre.

Operating in the 30-100 megacycle range, the two stations reflect radio signals off the meteor trails that occur about sixty miles above the earth's surface.

The constant bombardment of the ionosphere by meteors enables the transmission of radio signals for distances as great as 1500 miles. (The SRI-Bozeman link is about 800 miles.) The communications link takes advantage of the large signals which exist when a meteor trail happens to be properly oriented in respect to the Bozeman and Institute stations.

Intervals between meteor trails allow intermittent transmission of messages. Therefore, for maximum use of time, messages are sent at 600 words per minute, which is ten times the standard teletype rate.

The link employs equipment similar to that used by military and civilian agencies for short-range communications. However, by using signals reflected from meteor trails and the equipment which is specially adapted for intermittent transmission, the SRI-Bozeman system enables the long-range transmission of messages. The system permits effective communications with transmitters of substantially lower power than is needed for continuous transmission on ionospheric forward-scattered circuits.

**Anglo-French Radar Co-operation**

An agreement has been concluded between Decca Radar Ltd and Société Nouvelle d'Electronique concerning radar aerial systems. The new agreement allows a combination of the French aerials with Decca Radar high-powered transmitters and displays and marks an important step in Anglo-French co-operation.

**Botanical Garden for the Blind**

Gardens specially laid out for blind people have been created in several countries in recent years. There is one in Hove, Sussex, and The Hague, in the Netherlands, is the latest city to provide this amenity for the sightless. A botanical garden containing plants and flowering shrubs with particularly distinctive perfumes has been laid out, with specially elevated borders so that visitors can touch the plants as they wander round. Plaques with names in Braille characters are placed beside each specimen.

**Erratum**

The footnote to the "Progress of Science" item on "Tranquilizing Drugs", p. 456, incorrectly gave the London Publishers of the monograph as Academic Books Ltd. The actual publishers are Bailey Bros. & Swinfen Ltd.

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## FAR AND NEAR—continued

## 60-Ton Transport Vehicle

What is claimed to be one of the largest road transport vehicles in the world is being built in Sydney to take two pieces of industrial machinery from Sydney to the iron and steel works at Port Kembla. The vehicle, a semi-trailer weighing nearly 60 tons—has ninety-six wheels, and will transport machinery weighing 117 tons for the new Australian Iron and Steel Co.'s Port Kembla mill.

## Late Classified Advertisement

## LECTURES AND COURSES

## UNIVERSITY OF LONDON

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The following University Extension Courses will be held at Imperial College, beginning January 1958:

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## Lecturers:

R. W. B. Stephens, PH.D., A.R.C.S., D.I.C.

G. G. Parfitt, PH.D., A.R.C.S., D.I.C.  
(both of Imperial College).

This Course of Eight Lectures will be held at the

Physics Department, Imperial Institute  
Road, South Kensington, S.W.7

on Tuesdays at 7 p.m.  
beginning January 14

Fee for admission 10s.

## THE PHYSICS OF CLOUDS

## Lecturer:

J. Hallett, B.Sc. (of Imperial College).

This Course of Six Lectures will be held at the

Huxley Building, opposite Science  
Museum, Exhibition Road, South  
Kensington, S.W.7

on Thursdays at 6.45 p.m.  
beginning January 16

Fee for admission 10s.

The following University Extension Course of Eleven Lectures will be held at the

London School of Hygiene and Tropical  
Medicine, Keppel Street, W.C.1

on Tuesdays at 6.30 p.m.  
beginning January 14, 1958

Fee for admission 15s.

THE PRINCIPLES OF  
INSECT CONTROL

## Lecturers:

P. T. Haskell, B.Sc., PH.D., A.R.C.S.

T. R. E. Southwood, B.Sc., PH.D., A.R.C.S.

Applications for admission and further information should be made to the Deputy Director (Ext. D), Dept. Extra-Mural Studies, Senate House, W.C.1.

## Classified Advertisements

## OFFICIAL APPOINTMENTS

COMMONWEALTH OF AUSTRALIA  
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INDUSTRIAL RESEARCH ORGANIZATION  
DIVISION OF INDUSTRIAL CHEMISTRY  
APPOINTMENTS TO RESEARCH STAFF

The Organization's Division of Industrial Chemistry, which has a research staff of approximately one hundred, will make several appointments in the Research Officer classification during the next few months. The newly-appointed officers will be attached to one or other of the major Sections of the Division, which are:

- (1) Cement and Ceramics; (2) Chemical Engineering; (3) Chemical Physics; (4) Mineral Utilisation; (5) Organic Chemistry; (6) Physical Chemistry.

Potentially rewarding research projects are more numerous than can be staffed, and the Division's policy is to proceed only with those for which suitable staff can be recruited. It is not intended, therefore, to define closely the work to be done by the successful candidates. The types of investigations in progress can be ascertained from the Annual Report of the Division, a copy of which can be obtained from the Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2. Opportunities exist for both fundamental and applied research.

Enquiries or applications are invited from those seeking research experience or a research career in Australia. Whilst it is possible that additional vacancies may be available, the Division seeks, in particular, officers for work in each of the following fields:

- (a) CHEMICAL ENGINEERING: Studies of the technology of fluidized-solids systems, and their applications in metallurgy and coal utilization. (Reference number 590/648)
- (b) CHEMICAL PHYSICS: Theoretical and/or experimental studies in solid state chemistry. (Reference number 590/649)
- (c) MINERALS UTILIZATION: The chemistry of the less common metals, including Thorium. (Reference number 590/650)
- (d) MINERALS UTILIZATION: Hydrometallurgy: initially on studies of pressure leaching of minerals. (Reference number 590/651)
- (e) PHYSICAL CHEMISTRY: A study of novel adsorption and electrochemical processes. (Reference number 590/652)

In making appointments, the Division often attaches more importance to research ability rather than to intimate knowledge of a field of work. It may therefore expect a considerable measure of adaptability in its appointees.

Appointment to position (c) is for three years only in the first instance. Appointments to the other positions may be made for a fixed period of three years, or on a long-term basis depending largely on the wishes of the successful candidates. The appointments are also conditional upon satisfactory medical examinations. In the case of appointees domiciled overseas, first-class sea travel to Australia will be provided for the appointees, their wives and families. Those appointed for a fixed term will be provided with similar travel to return to their home countries should they not be chosen for indefinite appointments, or not wish to take up such appointments if offered. If indefinite appointments are made, the appointees will be required to contribute to, and eligible to receive benefits from, either the Commonwealth Superannuation Fund or the Commonwealth Provident Account.

Commencing salary will be determined according to the appointees' qualifications and experience, and will be within the salary ranges of Research Officer. £A1313-£A1938 p.a. or Senior Research Officer £A2048-£A2323 p.a.

Applicants should possess University Honours degrees, together with some post-graduate research experience, not necessarily in the fields covered by the above positions.

Applications quoting the reference number for the type of work in which the applicant is most interested, and stating full name, place, date, and year of birth, nationality, marital state, present employment, particulars of qualifications and experience, and of war service, if any, accompanied by copies of not more than four testimonials, and the names and addresses of three persons acquainted with you professionally should reach Mr. A. Shavitsky, Chief Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2., from whom further particulars may be obtained, by the 20th December, 1957.

EXPERIMENTAL OFFICERS AND  
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Departments. The Civil Service  
Commissioners invite applications for  
pensionable posts.

The posts are divided between following main groups and subjects: (a) Mathematical and Physical Sciences, (b) Chemistry and Metallurgy, (c) Biological Sciences, (d) Engineering subjects, and (e) Miscellaneous (including e.g. Geology, Library, and Technical Information Services).

**Age Limits:** For Experimental Officers, at least 26 and under 31 on December 31, 1957; for Assistant Experimental Officers at least 18 and under 28 on December 31, 1957. Extension for regular service in H.M. Forces. Candidates aged 31 or over with specialised experience for Experimental Officer posts may be admitted.

Candidates must have at least one of a number of specified qualifications. Examples are Higher School Certificate,

General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1957 may be admitted provisionally. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

#### Salary (London):

Experimental Officer. Minimum £970 (women £894); Men's scale maximum £1190.

Assistant Experimental Officer. Starting pay £385 (at 18) up to £685 (women £661) at 26; Men's scale maximum £850. Women's scales are being raised to reach equality with men's by 1961. Somewhat lower outside London. Promotion prospects.

Opportunities for further education. Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S94-95/57.

Interview Boards arranged at intervals, as required. Early application is advised.

**A**PPPLICATIONS are invited for pensionable posts as

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Starting pay for five-day week of 42 hours in London between £605 and £1120 (men), according to post-graduate (or equivalent) experience and National Service. Maximum of scale £1345. This salary scale is being increased by approximately 5%. Women's pay above £605 slightly lower but is being raised to reach equality with men's in 1961. Good prospects of promotion to Senior Examiner rising to £2000 (under review) and reasonable expectation of further promotion to Principal Examiner.

Application form and further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S128/57 and stating date of birth.

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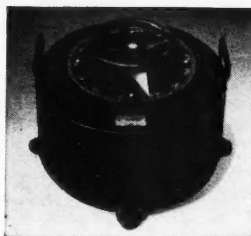
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